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THE

Philosophy of Chemistry.

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THE UNIVERSITY OF CHICAGO

PHILOSOPHY OF CHEMISTRY

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THE
PHILOSOPHY OF CHEMISTRY,
OR
FUNDAMENTAL TRUTHS
OF
MODERN CHEMICAL SCIENCE,
ARRANGED IN A NEW ORDER;

By A. F. FOURCROY.

TRANSLATED FROM THE FRENCH OF THE SECOND EDITION,
SIGNED BY THE AUTHOR.

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P R E F A C E.

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IN proportion to the advancement made by any science, and the improvement of it's progress by the acquisition of methodical procedures, will be the multiplicity of it's general truths. This is strikingly exemplified in the present state of chemistry. The principles of this science have been created but a few years; and it is already rich in corollaries, or general results, which embrace it's whole circumference. A chain of these results may be of infinite utility. For twelve years I have been constantly occupied in the investigation of this chain: and I have repeatedly presented a sketch of it in my lectures; particularly in those, which I deliver annually at the conclusion of my general and detailed course of chemistry. In the display of the phenomena exhibited by the elastic fluids with which we are acquainted,

acquainted, in their evolution, their fixation, and their influence on the operations of nature and art, I pass in review all the fundamental truths of the science; and from this survey results a picture, which recalls to the memory the changes of which natural bodies are susceptible in their reciprocal attractions. But in combining these grand truths, it is evident, that great discernment should be employed in the selection of those, which are most general, which embrace and involve all the facts of the science, and which may be deduced from it as corollaries or direct consequences. It is requisite also, that they be delivered with clearness and precision, without ambiguity or doubt: that too large a number of them be not accumulated, though they must be sufficiently numerous to have nothing essential omitted; and, finally, that they be disposed in such order, and follow in so natural a series, as to exhibit the elements of the science, and at the same time display their relative bearings and connections.

Such

Such are the ideas I have formed, and by which I have been guided in my search of these truths. I have imagined, that they might serve to establish a complete system of the doctrines of chemistry; which, as fertile in its applications as in its principles, should recall to the mind of the adept all the facts comprised within the vast domain of the science, and give to him who seeks instruction a competent notion of the career through which he has to run.

To accomplish effectually this object, I have conceived it necessary, not to deliver a series of detached, unconnected, and incoherent propositions; but to avail myself of their general relations, and give them an arrangement, which may enable the reader to discern and appreciate their connexion, and, if I may use the term, their reciprocal reaction. This is what I understand by the philosophy of chemistry. All the propositions of which it consists have been inserted in the Chemical Dictionary of the Encyclopedia, under the head of Axioms; but I shall render some service, I conceive, to the lovers

of this science by publishing them separate from that work, and in a more convenient form.

The success of my first edition of the Philosophy of Chemistry has induced me to publish a second, in which there are a few alterations, and some slight corrections, with scarcely any additions. Of many the work is not susceptible, unless the science should become enriched with new and important discoveries.

THE

PHILOSOPHY OF CHEMISTRY.

ALL the facts and experiences of chemistry may be referred to twelve general phenomena, which are the following :

1. The action of light.
2. The action of caloric.
3. The action of air in combustion.
4. The nature and action of water.
5. The nature and action of earths, and the formation of alkalies, with the parts they perform in combinations.
6. The nature and properties of combustible bodies.

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7. The

7. The formation and decomposition of acids.
8. The union of acids with earths and alkalies.
9. The oxydation and diffolution of metals.
10. The nature and formation of vegetable substances.
11. The transition of vegetables to the state of animal matter, and the nature of the latter.
12. Finally the spontaneous decomposition of vegetable and animal substances.

These twelve heads may be considered as so many chapters, to each of which belong those different articles of detail which have a direct relation to the head, while all of them, taken together, include the whole of the doctrines of chemistry.

C H A P. I.

THE ACTION OF LIGHT.

I. LIGHT, whether it come from the sun and fixed stars, or be diffused throughout space, has four different modifications with regard to the bodies with which it comes into contact; either it is reflected entirely from their surfaces to our eyes, and excites the sensation of whiteness; or it is decomposed, and some of its parts only are reflected, whence arise different colours; or it is more or less completely absorbed, and produces blackness; or, lastly, it passes through bodies, deviating more or less from its course, by approaching the perpendicular, and this constitutes transparency.

II. In its passage through transparent bodies, it experiences a refraction, the degree of which is in a direct ratio to the density of the body, if incombustible, but increas-

creasing in proportion to the combustibility of the body through which it passes. Hence Newton divined the combustibility of the diamond, and the existence of a combustible principle in water.

III. Light, in refracting, is decomposed into seven rays ; red, orange, yellow, green, blue, indigo, and violet. It has been supposed, that three of these colours, the red, yellow, and blue, were simple ; and that the other four were formed each of it's two neighbours ; that is, the orange from the red and yellow, the green from the yellow and blue, the indigo from the blue and violet, and the violet from the red and indigo. But this supposition has never been proved. The decomposition effected by means of the prism is a sort of analysis of light.

IV. Light also acts chemically on substances, occasioning decompositions and combinations. This we infer from the difference exhibited by bodies involved in light, from the same deprived of this element. The former become in general coloured, 5. volatile,

volatile, and inflammable; the latter have the opposite qualities.

V. Thus by the contact of light some acids are decomposed; many salts change their nature; the oxyds of metals in general re-approach the metallic state; and vegetables acquire colour, and become sapid and inflammable; while, deprived of light, they remain pale and insipid, they are what we call *etiolated*.

VI. These general effects are almost always owing to this circumstance, that light deprives burnt bodies of the principle they absorbed in burning, so that from incombustible, which they had become, they return to the combustible state. It may be said, that light generally *unburns* burnt substances,

Application of the preceding Propositions.

The colours of bodies.

Transparency.

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Opacity.

Opacity.

Brilliancy.

Simple and double refraction.

Metallic lustre.

The decomposition of acids, and of metallic oxyds.

Decombustion.

The alteration of the colours of minerals.

Vegetation.

The decomposition of water by the leaves of plants.

The renovation of the vital air of the atmosphere.

The formation of oils.

The difference between the vegetables of hot climates, and those of temperate ones, &c.

C H A P. II.

THE ACTION OF CALORIC.

I. WHAT we call *heat* is a sensation produced by a substance to which modern chemists have given the appellation of *caloric*. When caloric is applied to a man's body in a proportion more abundant than it already contains, his system is warmed, and with regard to him heat takes place. When, on the contrary, a substance of a lower temperature than his body is applied to it, he feels the sensation of cold, because he loses caloric.

II. Caloric penetrates all bodies; it separates their particles by lodging between them, and diminishes their attraction; it dilates bodies, it fuses solids, and it rarefies liquids to such a degree, as to render them invisible, give them the form of air, and convert them into elastic, compressible, aeriform

form fluids. Hence it follows, that liquids are combinations of solids with caloric, and gases are solutions of different bodies in caloric, which of itself is the most attenuate, subtile, light, and elastic of all natural substances; accordingly its weight cannot be estimated.

III. While caloric separates the particles of bodies, and diminishes their attraction for each other, it proportionally augments their attraction for the particles of adjacent bodies. For this reason it is successfully employed to produce combinations, and facilitate reciprocal unions. Hence the axiom, *corpora non agunt, nisi soluta*, bodies do not act, unless they be dissolved.

IV. Every particular body differing from others both in the form of it's particles and their separation from each other, it admits a different quantity of caloric to arrive at the same temperature; this is what is called *the capacity of bodies for caloric*. From this it follows that different bodies, at the
same

same temperature, really contain different quantities of caloric, though they raise the thermometer to the same degree.

V. This different quantity of caloric contained in bodies raised to the same temperature, which is with propriety termed *specific heat*, being incapable of being measured by the thermometer, a mode of ascertaining it has been invented, by means of the quantity of ice which bodies at an equal temperature will dissolve in descending to the same degree. The difference of the quantity dissolved gives the proportion of caloric contained in the several bodies, and the instrument employed to ascertain this difference is called a *calorimeter*.

VI. All the experiments made by the modern philosophers, who have investigated the theory of caloric, prove, that bodies, in changing their state, change also their capacity. We call change of state in bodies their becoming solid, liquid, or elastic fluid. Hence it follows, that by mixing two solid
bodies

bodies at different temperatures, incapable of combining together, a mean of the two temperatures will be obtained, if their capacities be equal ; but if their capacities be unequal, the temperature of the mixture will deviate more or less from the mean, and the difference will indicate the reciprocal capacities of the two bodies.

VII. The preceding phenomena show, that caloric has different attractions, or different degrees of affinity, for different bodies. In all combinations, therefore, this varying attraction of caloric should be attentively calculated.

VIII. When bodies unite, either they lose caloric, which indicates, that the new compound contains less than it's component parts ; and in this case the operation renders heat perceptible to our organs, and the temperature of the mixture is increased, which commonly takes place in our experiments : or the bodies which combine absorb caloric, and the new compound contains more heat than

than it's parts did separately; and then, when the combination takes place, the mixture grows cold, the caloric which was at liberty between it's particles unites with them more closely, and they even take some from the neighbouring bodies.

IX. Sometimes caloric adheres so forcibly to bodies, that it prevents their combining with others. Thus many dissolved into gas, or elastic fluid, unite neither with other bodies, nor with one another, as long as they retain this state of invisible solution in caloric; so that recourse must be had to double attractions to effect their combination.

X. The attraction of caloric for some substances is so great, that it is very frequently employed with advantage for separating these substances from the compounds into which they enter, and for analysing or decomposing compound bodies. This is what we do in distillation, and in all the decompositions effected by means of fire alone, or
caloric,

caloric, applied to very compound matters. The different elements of these compounds are gradually dissolved, in the order of their solubility in caloric, and separated in the state of vapour, or gas.

XI. Light, applied at the same time with caloric, frequently assists it's action, or has it's action assisted by it. Hence transparent vessels employed in furnaces are extremely useful to chemists, by transmitting light and heat at the same time. A similar effect is produced by penetrating opaque vessels so thoroughly with caloric, as to make them red-hot, or render them permeable to light.

XII. There are bodies, which absorb caloric much more speedily than others; this is called the property of *conducting caloric*. In general those bodies which are most coloured are the best conductors. The cause of this phenomenon is unknown.

XII. All

XII. All these facts demonstrate, that caloric is a particular substance, and not a modification of all substances, as some natural philosophers have imagined : and it is far from having been shown to be the same thing with light ; for the farther we advance in the science of physics, the more difference appears between the modes of action of these two substances.

Application of the preceding Axioms.

The dilatation of solids, and the rarefaction of fluids.

Thermometers.

Fusion.

Sublimation and volatilization.

The calorimeter, and tables of the specific heat of bodies.

The changes of temperature in different mixtures.

Artificial refrigeration.

The production of gases, and their fixation.

Dis-

Distillation at different temperatures.

Incandescence.

The different conductors of caloric.

The attractions of caloric.

C H A P. III.

THE ACTION OF THE AIR.

I. THE air acts in a collective mass on all natural bodies, by its weight, moisture or dryness, temperature, &c. Accordingly experiments of synthesis or analysis, made in contact with the air, differ considerably from those, which are performed in a vacuum, and it is always necessary to ascertain the state of the barometer, thermometer, and hygrometer, in chemical experiments.

II. The atmosphere is a vast laboratory, in which nature operates immense analyses, solutions, precipitations, and combinations : it is a grand receiver, in which all the attenuated and volatilized productions of terrestrial bodies are received, mingled, agitated, combined, and separated. Considered

sidered in this view, the atmospheric air is a chaos, an indeterminate mixture of mineral vapours, vegetable and animal molecules, seeds, and eggs, which the luminous, caloric, and electric fluids are pervading and traversing continually. The grand changes it experiences, of which we are sensible in extensive spaces by the appearance of water, light, free caloric, or noise, are called meteors.

III. Notwithstanding this mixture, of which it seems impossible for us to ascertain the nature, the atmospheric air is sensibly the same with regard to it's intimate qualities, wherever we examine it; and it is decidedly marked by it's two properties of supporting respiration and combustion. The closest analogy subsisting between these two grand phenomena, from a careful study of what passes in combustion we may acquire a knowledge of the air.

IV. A combustible body cannot burn without the contact of atmospheric air, or a
certain

certain matter extracted from it. Thus combustion cannot take place in a vacuum.

V. A combustible body cannot burn in a given quantity of atmospheric air, beyond a certain period. A hundred parts of this air contain only twenty-seven capable of supporting combustion ; when these twenty-seven parts have been absorbed by the combustible body, the combustion ceases, as the other seventy-three parts cannot any way contribute to it's support. Hence it appears, that atmospheric air is a compound of two different substances, setting aside a few matters foreign to it, which are mingled with it, but amount not to more than a hundredth part of it's bulk. Of these two substances, one supports respiration and combustion : this is termed *vital air* : the other is the reverse of it in both these respects, and is called *azotic gas*.

VI. Thus a body burning in the air effects a real analysis of this fluid. It separates from it and absorbs the vital air, which
C
augments

augments the weight and changes the nature of the burning body. The azotic gas which remains is lighter than the atmospheric air, extinguishes bodies in combustion, and kills animals. It is also one of the constituent principles of several compounds, as we shall see farther on, particularly of ammoniac, or volatile alkali, the acid of nitre, and animal substances.

VII. A combustible body which has burnt in atmospheric air, and absorbed all the vital air to which it is capable of uniting, can burn no longer in a fresh quantity of air: it has become incombustible, and frequently saline.

VIII. A body burning in atmospheric air never absorbs completely the twenty-seven hundredth parts of vital air it contains. To make a perfect analysis of the atmospheric air, and divest it entirely of this fluid, combustible bodies must be burnt in it repeated times.

IX. The

IX. The portion of air thus absorbed by combustible bodies, called above vital air, is also named *oxygen air*. The former name is derived from it's being the sole elastic fluid capable of supporting life: the latter is given it, because many bodies on absorbing it are rendered acid.

X. Combustion then consists in the fixation and absorption of vital air by the combustible body, and the decomposition of the atmospheric air by it's means. As the vital air only serves to support combustion, it is easy to conceive, that a very combustible body, capable of absorbing the whole of the vital air, may be employed to determine the proportion of the two atmospheric fluids: thus phosphorus is now used for the purpose of *eudiometry*, or to discover the purity of the atmosphere, that is to say, the proportion of this vital air which it contains.

XI. As vital air is a gas, and many combustible bodies, when they absorb it, render

it fixed, and cause it to assume the solid form, the vital air, when it is thus precipitated, loses the caloric, which held it in a state of solution, and gave it the elastic fluid form : hence the origin of the caloric disengaged, or of the heat produced, during combustion.

XII. Combustible bodies differ from each other, first, in the rapidity with which they absorb oxygen ; 2dly, in the quantity of it they absorb ; 3dly, in the proportion of caloric which they disengage from the oxygen absorbed ; and, by consequence, 4thly, in the greater or less degree of solidity of the oxygen they contain after being burnt.

XIII. Burnt bodies then may be defined to be bodies combined with oxygen : accordingly they are termed oxygenated, or oxygenated substances : and as the greater number of known bodies are either combustible, or already burnt, we may be allowed to suspect, that many incombustible natural bodies,

dies, with the composition of which we are unacquainted, are incombustible solely from being saturated with oxygen. With regard to some in this predicament, this conjecture has already been verified.

XIV. From several of the preceding axioms it follows, that, when we burn a combustible body in order to procure heat, as we do to mitigate the rigours of winter, we obtain at least the greater part of the caloric from the air itself, with which it was combined. We may even assert, that the colder the air, the more heat is derived from it; because, when the atmosphere is extremely cold, more air passes into the fire in a given bulk. Indeed it is well known, that the fire in our grates is much more scorching, and burns much more briskly, when the air suddenly becomes cold; and the art of increasing combustion by means of condensed air thrown from a pair of bellows on wood already heated is founded on this principle.

XV. Combustion, then, is not confined to the decomposition of atmospheric air by absorbing one of its principles ; for it also decomposes the vital air, by absorbing, fixing, and rendering more or less solid, in the combustible body, the oxygen, or base of the vital air, and disengaging the solvent of this base, caloric, in greater or less quantity.

XVI. There is another interesting phenomenon in combustion, which modern chemistry is able to explain : that of the disengagement of light, or the production of flame. It is demonstrated, that the greater part of the light which constitutes flame is contained in the vital air, of which it is one of the principles : for 1st, combustible bodies afford much more flame when they burn in vital air alone, than in atmospheric air : 2dly, there are combustible bodies which do not burn with flame except in vital air : 3dly, to disengage the oxygen from bodies which contain it, and convert it into vital air, it is not sufficient to dis-

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solve

solve it in a greater or less quantity of caloric, but it is necessary at the same time to add light: 4thly, there are burnt bodies which lose their oxygen on the contact of light alone: in this sense we must understand the property of *unburning* and *decomposition*, mentioned as a characteristic of light in the first chapter.

XVII. Vital air, therefore, is to be considered as a compound of a solidifiable, ponderous, acidifying base, *oxygen*, dissolved in two menstrea, caloric and light, which of themselves are extremely attenuate, highly elastic, and destitute of assignable weight. Combustion consists in a more or less complete precipitation of the oxygen of these two menstrea.

XVIII. Thus a combustible body in burning disengages from vital air not only caloric, but also light; and every combustible body disengages a different quantity of light from the vital air, as it does of caloric. It is probable, that there are combustible

bodies which separate from vital air more light than caloric, while others disengage from it more caloric than light.

XIX. The oxygen fixed in burnt combustible bodies remains more or less deprived of light and caloric: and the density or solidity it acquires in the process is one of the causes, to which is owing the greater or less facility experienced in separating the oxygen from burnt bodies in the form of vital air. For this some require more caloric than light; others, more light than caloric.

XX. It is easy to perceive, after what has been said, that to separate the oxygen from a burnt body is to perform an operation the reverse of combustion. We have no word in our language to express this operation. It would not be improper to say, that we *unburn*, that we *difoxymate* the body: hence the terms of *unburning* and *difoxydation*.

XXI. Beside

XXI. Beside the greater or less force with which oxygen is retained in combustible bodies, according to it's being combined with them in a state of greater or less solidity, and it's having lost a greater or less portion of it's solvents, it adheres to them by it's attraction, it's particular affinity to each. A considerable number of these affinities of oxygen for different substances are already known, and the degrees of some of them have been ascertained.

XXII. It is from the degrees of these affinities, that we are frequently enabled to transfer oxygen from a burnt body to a combustible one. In this process a combustion takes place, so much the more imperceptibly, or tacitly as it were, according as the oxygen is more solid in the burnt body, and more similar in density to the body which absorbs it, or into which it passes. But this kind of combustion sometimes takes place with a vivid heat and flame: which phenomena occur, whenever the body which is to receive the oxygen
must

must contain it in a more solid form, than that from which it is extracted. Thus iron, zinc, antimony, arsenic, &c. burn with flame, when heated with oxyd of mercury, from which they attract the oxygen, to contain it in a more solid form.

Applications of the preceding Propositions.

The obstacle which air opposes to evaporation, the ebullition of liquids, sublimation, &c.

The solution of water in air, and the hygrometrical state of the atmosphere.

The efflorescence and deliquescence of saline bodies, &c.

Aqueous meteors.

Experiments made at different heights of the atmosphere.

Experiments made in a vacuum.

The comparative nature of combustible bodies.

The increase of weight and change of nature in these bodies after combustion.

The

The history of native burnt bodies.

Artificial heat and flame.

The theory of furnaces.

The different eudiometrical processes.

The respiration of different animals.

The mephitism occasioned by combustion and respiration.

The diminution, increase, and support of animal heat.

Transpiration from the skin and lungs,
&c.

C H A P. IV.

THE NATURE AND ACTION OF WATER.

I. WATER exists in three different states : that of a solid, which is ice ; that of a fluid, it's most common form ; and that of vapour, or gas.

II. Ice is a crytallization more or less regular, transparent, very sapid, elastic, fusible at a temperature above 32° of Fahrenheit's thermometer, and which suffers the escape of much caloric from it's interior, in several combinations.

III. Ice at 32° absorbs 112° of heat in melting, or such a quantity of caloric as would raise a body of water of equal bulk with itself to 144° . It's capacity, therefore, is not the same with that of fluid water, which is owing to the difference of it's state, as has been said in Chap. II, Sect. VI.

IV. Whenever fluid water loses much caloric on entering into any combination, it ought to be considered as solid in it: frequently it is even much more so than ice at 32° ; whence arises the solidity of mortars, or cements, of which flaked lime form a part.

V. Water remains eternally solid on mountains, cooled for ages by the presence of ice, and underneath the poles. In these places it forms a kind of rocks, or white concretions almost similar to stones.

VI. Fluid water is pure, insipid, destitute of smell, and 850 times heavier than air. It forms rivers, brooks, ponds, springs, rivulets, &c. It occupies the cavities, furrows, and generally speaking, the lowest parts of the globe.

VII. It is very seldom pure, for it dissolves, in the earth, and on it's surface, air, saline gases, and terrestrious salts: it acts even on the most solid stones, which it dissolves, carries
along

along in it's course, deposits, and crystallizes. Hence it has been named the grand menstruum of nature. By it are produced various phenomena, and it is one of the most powerful agents, by which the surface of the globe is incessantly modified. It's mechanical and chemical operations have gradually changed the nature of minerals, and created a kind of new world on the face of the old.

VIII. Accordingly all the waters of the earth contain some substance or other, foreign to the nature of water; the presence of which is discernible from the increase of their specific gravity, their taste, more or less flat, earthy, and crude, and the difficulty with which they boil, dress pulse, or dissolve soap. The more free any water is from these properties, which are repugnant to it's essential character, the greater it's purity.

IX. Water flowing in a sandy channel, and exposed to the open air, is sufficiently pure for the purposes of life, and most of the
uses

uses of the arts. On the contrary, that which traverses chalk, gypsum, and marbles, or stagnates on turf, bitumen, and ores of metals, or in subterranean cavities far from the contact of the atmosphere, is more or less impure.

X. The art of correcting hard or impure water by chemistry consists in exposing it to the atmosphere, agitating it in contact with the air, boiling it, distilling it, and afterwards combining it with air. Frequently the addition of ashes, alkalies, or weak acids, serves to diminish the bad qualities of water ; and sometimes even completely removes them. Most adventitious substances, which diminish the purity of water, being either much more volatile, or much more fixed, than it, distillation is the most certain method of obtaining pure water. For this reason chemists always employ distilled water in their experiments.

XI. Fluid water, being a combination of ice at 32° , and such a quantity of caloric as
would

would have been sufficient to raise the water to 144° , on the addition of caloric becomes rarefied: when it is raised to a temperature of 184° , it assumes the form of gas, it is vapour: in this state it is far lighter than fluid water, it occupies a much more extensive space, it easily penetrates all bodies, it readily dissolves in air, and its expansive force renders it capable of moving enormous weights.

XII. As fluid water absorbs air, which renders it light, air also absorbs and dissolves water. This is the cause of water's evaporating. The solution of water in air is dry and invisible as air itself: it is proportionate to the temperature of the atmosphere. The hygrometer does not indicate with precision this water, for it is not affected by a complete solution of water in air, but moves according to the quantity of water which is just going to be dissolved, and more especially of that which is precipitating from it.

XIII. Water

XIII. Water is not a simple substance, as had long been supposed. By burning with rapidity a number of combustible bodies, more or less heated, as charcoal and pit-coal already on fire, red-hot iron, zinc melted and red-hot, oil, &c., water is decomposed, yielding to these combustible bodies the oxygen it contained.

XIV. In proportion as the oxygen of the water becomes fixed in the combustible bodies which it burns, it's other principle capable of dissolving in caloric forms the inflammable gas which is evolved. As this second principle is one of the elements of water, it has been called *hydrogen*, and it's elastic fluid solution in light and caloric hydrogen gas. The disengagement of this principle in the form of gas, which takes place wherever water is decomposed by a combustible body, is the cause of a great number of the detonations and fulminations, which occur in chemical processes.

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XV. The

XV. The hydrogen gas produced in various experiments always originates from water, either in consequence of a preceding decomposition, in which it had been combined in the state of fixed hydrogen, with one of the substances employed, or from a decomposition of water actually taking place in the experiments themselves. All hydrogen gas, therefore, proceeds from water.

XVI. Reiterated experiments have proved, that water contains about 85 hundredth parts of oxygen and 15 of hydrogen. The re-composition of water, one of the grandest discoveries of modern chemistry, confirms the analysis of this body ; for on uniting by combustion 85 parts of oxygen with 15 of hydrogen, a hundred parts of pure water are obtained.

XVII. When water is decomposed by a combustible body, this is effected by means of a double affinity ; that of the oxygen of the water for the combustible body, and that of it's hydrogen for caloric. For this reason,
the

the more caloric matter is employed in the experiment of decomposing water by means of iron, charcoal, or the like, the sooner is the water decomposed. From this necessity for an extreme abundance of caloric in the operation, it is easy to conceive how the hydrogen, one of the elements of the water, acquires a levity so far beyond that of the fluid from which it is derived : in fact, while a cubic foot of water weighs seventy pounds, a cubic foot of pure hydrogen gas weighs only sixty-one grains.

XVIII. Hydrogen gas, though always produced by the decomposition of water, carries along with it various substances, either suspended or dissolved in it, according as the bodies from which it is extricated are more or less simple : thus it is mingled with azotic gas, carbonic acid gas, or vital air ; or it holds in solution water, coal, sulphur, phosphorus, arsenic, oil, alcohol, ether, &c. From the difference of these adventitious substances which it contains, it varies in smell, weight, and inflammability, the

colour of the flame it yields, it's action on different bodies, and also in the products distinct from pure water which it affords in burning. Hence are derived the several species and denominations of inflammable gas admitted by authors, of which hydrogen gas always constitutes the general basis.

XIX. Hydrogen gas being one of those natural substances that contain most caloric, it is among the number of combustible bodies which give out most, and consequently afford most heat in burning. Hence all compound combustible bodies, of which hydrogen constitutes the basis, such as oils, fats, and in general all that originate from organized bodies, yield, during the process of burning, a considerable quantity of heat. Wood, oil, pit-coal, bitumen, alcohol, ether, and the like, are of this kind.

XX. It follows, also, from what has been said, that those compound combustible bodies, which contain much hydrogen in their composition, necessarily require a large
portion

portion of oxygen in burning, and afford water as a product of their combustion, in proportion to the quantity of hydrogen they contain. Thus a pound of alcohol, on being burnt, yields more than a pound of water, &c.

XXI. The combustible bodies which decompose water, generally speaking, are those which have a greater affinity, or stronger attraction, for oxygen, than hydrogen has: but this attraction is greatly assisted by the presence of caloric, which has a tendency to unite with the hydrogen. A large quantity of caloric can even occasion the decomposition of water by bodies which would be incapable of decomposing it cold. To this light equally contributes.

XXII. The combustible bodies which will not decompose water at any temperature, in consequence of their feeble attraction for oxygen, which in this case always remains inferior to that which subsists between oxygen and hydrogen, must, on

the contrary, when they have been burnt by other means, be decomposed, or suffer their oxygen to be taken from them, by hydrogen. This happens to the oxyds of lead, bismuth, &c.

XXIII. Hitherto the art of chemistry has arrived at the knowledge of no means of decomposing water, but by combustible substances, which take from it it's oxygen: we are unacquainted with any capable of attracting it's hydrogen, and setting it's oxygen free. It would seem, however, that nature has instruments for effecting this inverse manner of decomposing water: the leaves of vegetables struck by the rays of the sun appear to decompose water by absorbing it's hydrogen, and disengaging it's oxygen in the form of vital air. This we may presume to be in part the mechanism of vegetation, of the formation of oils, and of the renovation of the atmosphere. See Chap. IX.

XXIV. While hydrogen and oxygen, each dissolved into gas by caloric and light,
remain

remain in contact with each other cold, they do not combine ; no inflammation occurs, no water is formed. But if the mixture be exposed to an ignited body, strongly compressed, or affected by any violent and forcible concussion, a combination of the two commences, combustion takes place, and water is produced.

XXV. A similar phenomenon appears to take place in the atmosphere. Atmospheric detonations, claps of thunder, seem to be nothing more than a combustion of hydrogen gas and vital air ; and accordingly they are often succeeded by a torrent of rain. Some storms of rain also appear to be in like manner owing to a sudden formation of water in the atmosphere, from the rapid combustion of hydrogen gas and vital air, occasioned by an electric spark, arising from the necessary re-establishment of an equilibrium of electricity between different clouds, or between the clouds and the earth.

XXVI. A multitude of chemical phenomena of nature and art, formerly inexplicable and ranked as miraculous, are now esteemed the necessary consequences of the decomposition of water well understood. Of the truths exhibited in this chapter the influence on the general theory of chemistry is immense, as will appear in those that succeed.

Applications of the Propositions in this Chapter.

Artificial refrigerations.

The theory of the permanent ice covering the tops of mountains, and the neighbourhood of the poles.

The varieties of atmospheric and terrestrial waters.

The art of correcting the bad qualities of waters.

The theory of the ebullition of water.

The difference between boiled water and water pregnant with air.

The

The distillation of water in the great,
and that of salt water.

The theory of fogs and dew.

The theory of the hygrometer, and hygrometrical phenomena.

The burning of combustible substances
by means of water.

The gases disengaged from stagnant waters.

The variety of inflammable gases.

The colouring of substances by inflammable gases.

The oxydation of metals, or rust, produced by damp air.

The theory of detonations.

Some phenomena of metallic solutions.

Some fundamental principles of the theory of vegetation, the formation of oils, &c.

C H A P. V.

THE NATURE AND ACTION OF EARTHS
AND ALKALIES.

I. WHAT was formerly called earth by way of eminence, and considered as an element, and the cause of solidity, dryness, infipidity, indissolubility, &c., is now consigned to that class of vague and indeterminate ideas, which the imagination, unsatisfied with the success of experience, invented to supply the place of facts. At present no elementary earth is acknowledged; and instead of one earthy substance, we have at least five, all of which have an equal claim to be denominated elements, for each enters into the composition of various bodies.

II. Of the five earthy substances that have been discovered, two are in some measure more earthy, dry, susceptible of hardness,

ness, insipid, &c.; while the other three possess saline properties, which render them somewhat akin to the substances denominated alkalies. These three, which have in consequence been termed salino-earthly, saline earths, alkaline earths, and earthy alkalies, are baryt, magnesia, and lime. The other two are silex and alumin.

III. The generical characters common to all these are dryness, unalterableness in the fire, infusibility, and the quality of being insusceptible of decomposition, and acting as simple and indestructible substances in combination. Beside these, each has specific characters by which it is distinguished.

IV. Silex, which has been named siliceous earth, quartzose earth, and vitrifiable earth, is rough to the touch; it scratches and wears away metals; it is infusible, incombustible, insoluble in water and most acids, soluble by alkalies in a strong fire, and forming glass with these salts. It is found
in

in abundance in sand, quartz, flint, agate, jasper, sandstone, and all stones that strike fire, of which it constitutes the basis. It has neither been analysed, nor imitated by synthesis. Some have considered it as the most simple of the earths, the terreous element, the origin of all the other earths; but experience has not supported their assertions. It is employed for various purposes, particularly for mill-stones, and making glass, cements, earthen-ware, &c.

V. Alumin, so named because it constitutes the basis of alum, the same which some authors have called argil, is soft to the touch, and adhesive to the tongue, it hardens in the fire, makes a paste with water, unites with most acids, dries in flakes, acquires great hardness when mixed with water and filix, and is contained in a large proportion in clays, schists, steatites, &c. It is employed for various purposes of art, from it's aptitude for moulding into different forms, and retaining them, and it's qualities of hardening in the fire, and holding

ing water. By some it has been erroneously considered as filex changed, attenuated, and rotted by the action of air and water, but with it's intimate nature, or principles, we are totally unacquainted.

VI. Baryt, or *heavy earth*, is remarkable for it's extreme ponderosity. This is never found alone in nature, but always united with the sulphuric or carbonic acid. In the fire, and in contact with the filex or alumin of the crucible, it assumes a blue or green colour; it is soluble in nine hundred times it's weight of water, changes syrup of violets green, has a stronger affinity even than alkalies for most acids, and will any where detect the presence of sulphuric acid, and indicate it's quantity. It's principles are unknown, though it is suspected of being a metallic oxyd.

VII. Magnesia is very fine, very white, unalterable in the fire, soft, and light. It resembles vegetable feculæ, requires near two thousand parts of water to dissolve it,

very slightly greens the tincture of of violets and mallow flowers, forms with acids extremely soluble salts, and is less retentive of acids than lime, which attracts them from it, having nearly the same affinity for them as ammoniac, with which and acids it forms salts with two bases, or a class of triple salts. It exists in considerable quantity in serpentines, mica, slates, and amianthus; is equally incapable of analysis with the preceding earths; and, like their's, it's composition is unknown.

VIII. Lime is the most alkaline of earths, and the only one that possesses an acid, burning, almost caustic, disagreeable, and urinous taste. It is very powerful in converting the syrup of violets to a green colour; attracts water from the atmosphere when slacked in it; heats greatly with water, and becomes solid with it; gives out a large quantity of caloric when slacked dry; dissolves in less than seven hundred parts of water; attracts carbonic acid from the atmosphere, and forms on the surface of it's

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solution

solution a pellicle of chalk, improperly called *cream of lime* ; is unalterable alone, but melts with filex and alumin ; and is formed of principles with which we are yet unacquainted, though it is evidently a compound.

IX. The pretended conversion of earths, each into other, admitted by natural philosophers, is nothing more than a chimera : so far is it from being proved, that filex becomes alumin in consequence of exposure to the air, that flints are changed into chalk, and that chalk is converted into magnesia, as some have supposed on much too feeble grounds.

X. The three alkaline earths are to appearance more manifestly compound than the other two. There is reason to presume, that azot is one of their principles, and gives them their alkaline properties : however, experience has yet afforded no proof in support of this opinion ; though their origin, ascribed with considerable probability to
marine

marine animals, which contain a large portion of azot in their composition, renders it not destitute of foundation.

XI. As to the metallic nature of the five earths, which some supposed they had demonstrated by an imaginary reduction of them into metals, by exposing them to a violent heat in contact with charcoal; the very small and few metallic globules obtained evidently came from the charcoal and the earth of the cupels, and has been discovered to be nothing more than phosphur of iron in the treatment of each of the different earths; whence it is sufficiently proved, that they afford no metallic substance. Several natural philosophers continue of opinion, that earths are species of burnt bodies, to which the oxygen is strongly adherent, and incapable of being decomposed on account of their powerful attraction for this principle; but in this they are not supported by experience.

XII. Earths

XII. Earths combine by twos, threes, and even greater numbers, by processes unknown to us, which nature employs on a very extensive scale, to produce stones differing in hardness, texture, transparency, opacity, colour, form, &c. If art have failed to imitate these compounds, the reason is, time, space, and quantity, are wanting. Something similar to the natural earthy compounds, however, may be produced, by leaving a long time in contact earths, intimately mingled, and moistened at first with a little water.

XIII. The three alkaline earths form a kind of intermediate link between earths and alkalies. The latter are distinguishable by their acrid, burning, and urinous taste, their causticity, their singular action on the skin and all animal substances, the quality of changing the blue colour of violets to a green, and even a greenish yellow, and deliquescency. We are acquainted with three species, potash, soda, and ammoniac. The first and second have been called *fixed alk-*
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lies,

lies, because they melt and grow red in the fire before they become volatile ; the third has been named *volatile alkali*, from possessing the opposite property.

XIV. Potash is known by the following characters :—It is dry, solid, white, crystallized in rhomboidal plates, fusible at a temperature of 203° , and very deliquescent, absorbs water with heat and a peculiar faint smell, combines with silice by fusion, and forms with it a transparent compound. It is frequently found native with lime, and combined with different acids ; but is chiefly obtained from vegetables, in the ashes of which it remains after combustion. It is supposed, that it bears some analogy to lime, and may perhaps be formed of azot combined with it : experience, however, gives support to this opinion.

XV. Soda is procured from marine plants by incineration, and constitutes the basis of sea-salt. It strikingly resembles potash in form, causticity, fusibility, deliquescency,

quescency, combination with silex by means of fusion, action on animal substances, &c. ; so that it was long confounded with it, and might have continued to be so, if it did not form very different salts with acids, and yield these acids to potash. It has been imagined, that soda was a compound of magnesia and azot, because salts with soda for their base have been as frequently found with salts having for their base magnesia, as calcareous salts with those having potash for their basis: but both these opinions remain hitherto equally devoid of proof.

XVI. Ammoniac, or *volatile alkali*, differs greatly from the two preceding species in it's form of gas when dissolved in caloric, in it's fluid form when dissolved in water, in it's pungent and suffocating smell, it's solubility in air, and it's known and easy decomposition by the electric spark, metallic oxyds, and the nitric and oxygenated muriatic acid. This decomposition evinces, that ammoniac is a compound of hydrogen and azot; and for this reason it frequently exhi-

bits the phenomena of a combustible substance. Hence also it is easy to conceive, how animal matters furnish ammoniac in consequence of putrefaction.

XVII. If azot should at some future period appear to be the principle that forms alkalies, the atmosphere will be found to consist of a mixture of oxygen and alkaligen, each separately dissolved in caloric; and it will exhibit an immense reservoir, from which the philosopher will perceive nature drawing the materials of two classes of compounds, the most active and useful in a great number of her operations.

Applications of the Propositions in this Chapter.

The extraction, preparation, and purification of earths.

The theory of the arts of the potter, brickmaker, &c.

The theory of cements and mortars.

The

The reciprocal combinations of earths
by means of fire.

The natural history of stones.

The compound nature of earths and
stones.

The alteration of colours by means of
alkalies.

Vitrification and the art of making glafs.

The extraction and purification of potash
and soda.

The theory of alkaline caustics.

Some points regarding putrefaction.

C H A P. VI.

THE NATURE OF COMBUSTIBLE BODIES.

I. COMBUSTIBLE bodies are too various, numerous, and important in the phenomena they exhibit, and the combinations they are incessantly entering into with each other and with the air, not to excite us to examine them with care, and endeavour accurately to ascertain their properties and specific characters.

II. In comprehending under this name all substances capable of combining more or less rapidly with oxygen, and disengaging from it caloric and light, we should arrange them in two classes; simple or indecomposable combustibles, or such as cannot be decomposed, and combustibles more or less compound.

III. We

III. We call those combustibles simple, which we are hitherto unable either to decompose, or to compose by the union of different substances. With their intimate nature we are unacquainted. Sometimes they occur singly in the mineral kingdom, or in one of the others ; but they are found most usually combined two and two together. Such are the diamond, hydrogen, sulphur, phosphorus, carbon, and the metals. Each of these six genera must be considered separately.

IV. The diamond is the hardest of all the bodies that we know. It is very remarkable for the power with which it refracts and decomposes light, from which Newton discovered, that it was very combustible. It is found native, crystallized in octaedra, dodicaedra, &c. ; exhibits some varieties differing in texture, density, and colour ; burns with a perceptible flame, and is converted into vapour by burning. It's combination with oxygen is unknown. Few substances act upon it ; and, if it were not

E 4 combustible

combustible, it might be considered as insusceptible of alteration. We know no compound into which it enters as a constituent part; and it seems of all bodies the least obedient to chemical attraction.

V. Hydrogen is one of the principles of water. With caloric and light it forms hydrogen gas, sixteen times as light as air, insoluble in most substances, capable on the other hand of dissolving sulphur, phosphorus, carbon, arsenic, oils, &c., and thus forming the different species of inflammable gas, formerly called sulphurated, phosphorated, carbonated, arseniated, oleaginous, &c. hydrogen gas. It decomposes several metallic oxyds, and acids with simple and known radicals; imparts to all the compounds into which it enters, whether they be combustible or not, a considerable refringent power, which property led Newton to conjecture, that a combustible substance was contained in water; becomes fixed in organized bodies, and forms one of the principles of the mixed combustibles

combustibles they contain. See Chapters IV, and X.

VI. Sulphur is a yellowish substance, odorate, electric, transparent and octaedral, opake and prismatic, and fusible. It is susceptible of two kinds of combustion ; the one slow, with a blue flame, and the formation of sulphurous acid ; the other rapid, with a white flame, during which sulphuric acid is produced. It combines with earths and alkalies ; becomes soluble when thus combined ; unites with metals, and forms sulphurous ores ; and exists in the earth in very large quantity, either alone, or combined with metal.

VII. Phosphorus is a white, transparent, crystallized, lamellated, and extremely fusible substance. It burns in two modes ; slowly, in every temperature with which we are acquainted, emitting a white flame and acid odour, and forming phosphorous acid ; rapidly, in a temperature of 147° , with a vivid and very brilliant flame, without any perceptible

perceptible odour, and forming phosphoric acid. It is never to be found pure in a native state, on account of its extreme combustibility ; unites with sulphur, and with metals ; is soluble in hydrogen gas ; takes away oxygen from several metals, and separates them from acids, restoring their proper form, and metallic lustre ; and exists more abundantly in the mineral kingdom, even than in the animal, to which it was once exclusively attributed.

VIII. Carbon is the combustible matter of coals, supposed pure and isolated from earths, alkalies, salts, &c. It is combustible in a great degree of heat ; forms carbonic acid when united with oxygen ; has the strongest attraction for oxygen of any known substance, and deprives all other burnt bodies of this principle ; exists in abundance in animals and vegetables, constituting almost wholly the solid basis of the latter, and on that account remaining, and preserving their form, after they are decomposed, either spontaneously or by the action
of

of caloric ; is soluble in alkalies, and hydrogen gas ; unites with metals, forming with iron, in particular, steel, and carbure of iron, improperly called *plumbago*, *lead ore*, or *black lead* ; and is found in each of the natural kingdoms.

IX. Metals are well known for their great ponderosity and lustre : they are fusible, crystallizable, and combustible ; decompose water and several acids ; unite with sulphur, phosphorus, carbon, and each other, at different temperatures ; and in their state of oxyds perform a double function, that of acids with earths and alkalies, and that of salifiable bases with acids. This genus differs from all that precede particularly in the number of it's species. To give a just idea of these, of which there are seventeen with which which we are well acquainted, and this number will probably be still farther increased by new researches, I shall divide this genus into five sections : in the first I shall comprise brittle and acidifiable metals, of which there are three, arsenic,

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tungsten,

tungsten, and molybdæna : in the second I shall rank those which are brittle, and simply capable of oxydation, of which I reckon five species, cobalt, bismuth, nickel, manganese, and antimony : the third section will include the semi-ductile and oxydable, of which there are two, zinc, and mercury : the fourth section will be assigned to such metals as are perfectly ductile, and easily oxydable, which are tin, lead, iron, and copper : and the fifth will comprehend those that are perfectly ductile, but oxydable with difficulty, which are silver, gold, and platina. As the ninth chapter is reserved for the most important chemical properties of metals, it will be sufficient here to exhibit briefly some specific differences of each of these bodies ; observing, that the appellations of *semi-metals*, *imperfect metals*, and *perfect metals*, manifestly originating from the erroneous ideas of alchemy, ought to be discarded from the language of a science, that has any pretension to accuracy.

A. Arsenic is lamellated, of a bluish gray colour, brilliant, and fragile; and burns with a blue flame, and a smell resembling that of garlic.

B. Tungsten is of a gray white colour, granulated, friable, almost infusible, and scarcely soluble in acids, though extremely oxydable and acidifiable by the operation of air and caloric.

C. Molybdæna is in the state of powder, or grains, blackish, shining, agglutinated, fragile, very little fusible, and by burning becomes a white, volatile, prismatic, and acidifiable oxyd.

D. Cobalt is granulous, fine, of a rosy white colour, fragile, pulverable, difficult of fusion, and becomes blue when melted with glass.

E. Bismuth is in large laminæ, of a yellowish white, brittle, easily fusible, very crystallizable, and extremely oxydable.

F. Nickel

F. Nickel is gray, granulous, hard, a little fragile, extremely difficult to fuse, and affords a green oxyd by means of caloric and air.

G. Manganese is of a gray white colour and fine grain, brittle, very difficult to fuse, and of all metals the most combustible in the air alone, so that it changes colour immediately on exposure to it, and is reduced to a black dust in the course of a few days. It should be kept underneath alcohol, or oil, to prevent it from burning.

H. Antimony is of a pure white, in large laminæ, brittle, hard to fuse, and sublimes on combustion in the air into a white, crystallized oxyd, which almost acts the part of an acid in uniting with alkalies.

I. Zinc is of a blue white colour, in large laminæ, semi-fragile, in some degree malleable, easy to fuse, the most inflammable of metals, burning when red hot with a beautiful yellowish white flame, and powerfully decomposing water.

K. Mercury

K. Mercury is fusible at 30° below 0 of Reaumur's thermometer, and congeals at 31° , becomes a black oxyd (*æthiops per se*) by mere division, or is extinguished by this simple process in every viscous or consistent matter with which it is triturated.

L. Tin is of a brilliant white colour, soft, light, little sonorous, capable of being scratched by the nail, very fusible, very combustible, and affords a white oxyd, which destroys the transparency of glass, and converts it into enamel.

M. Lead is of a dull bluish colour, heavy, soft, extremely fusible, and affords an oxyd the most vitrifiable of all we know, and a glass of a yellow hue resembling that of a topaz.

N. Iron is white, fibrous, the most tenacious of metals, very difficult to fuse, very combustible, and the only metal attracted by the magnet. It readily decomposes water, changes to a powder in the
air,

air, unites with carbon, which converts it into steel, and is the only metal any way abundant in the two organic kingdoms.

O. Copper is of a fine shining red, very soft and ductile, odorate, and poisonous. It burns with a green flame, and affords brown, blue, and green oxyds, the last of which is formed in damp air.

P. Silver is of a pure and brilliant white, destitute of smell and taste, very ductile, not oxydable by caloric and air, burning with a greenish flame by the electric shock, growing black from the fumes of sulphur, unalterable by the air alone.

Q. Gold is of a fine brilliant yellow, extremely ductile, less combustible and less oxydable than silver, and even still less alterable than it by the contact of air. It is convertible into a fine purple oxyd by the electric shock.

R. Platina

R. Platina is the heaviest, most infusible, least combustible, and least alterable of all metals. It is of a gray white colour, possesses little brilliancy, and will at some future period become one of the most valuable instruments of the arts.

X. Compound combustible bodies are all such as result from a combination of some of the preceding ones : thus the solutions of sulphur, carbon, phosphorus, and arsenic, in hydrogen gas, are inflammable gases : and the combinations of sulphur with phosphorus, of carbon with iron, of different metals with sulphur, phosphorus, and each other, are compound bodies. Such are almost all the combustibles we meet with in nature : it is the province of art to separate them from each other, and exhibit them pure and isolated.

XI. When we compare the properties of compound combustible bodies with those of simple combustibles, we perceive, that the former sometimes absorb oxygen with more

F avidity

avidity than if they were alone, as many metallic sulphures, and alloys ; at other times, on the contrary, we find them less ready to burn, on account of the strong attraction they possess for each other, which is the case in general with phosphorated metals. There are even some that are long unalterable in the air, appearing to have lost by their intimate combination the property of being combustible, which they exert only when strongly heated ; as the carbure of iron, which is even employed with some success to prevent iron from contracting rust.

XII. Hydrogen and carbon, very intimately united together in the capillary tubes of vegetables, and frequently containing small portions of earths, alkalies, acids, and especially oxygen, from bitumens, oils, and resins, which, though they have a tendency to burn and separate, preserve some time the equilibrium of their combination, till a rapid increase of temperature, accompanied with the contact of air or water, puts an end to this equilibrium, by isolating their
elements,

elements, and uniting them separately with oxygen. Accordingly the products of these compound combustibles are universally water and carbonic acid. It is the same with alcohol, and with ether, formed by modifications of the principles of vegetable matter, which, in their ultimate analysis, are nothing else than combinations of hydrogen and carbon with more or less oxygen and water. See Chapters X, XI, XII.

XIII. This exhibition of the different species of combustible bodies, and their principal characteristic properties, shows the part they act in the phenomena of the globe. It authorizes us to divide almost all the productions of nature into two grand classes, one of combustible bodies, the other of bodies already burnt: in the masses and action of the former we discern the causes of inflammable meteors, partial heat, volcanoes, the perpetual alterations of the surface of the earth, &c.; in the existence of the latter, we perceive the source of the number and diversity of acids, saline compounds, oxyds, and metallic salts, which

vary in a thousand ways the appearance of ores, their reciprocal decomposition, and their alterations by the action of water, air, and light ; in fine, we discover in vegetables machines which nature has organized for the purpose of intimately combining several of these substances with each other, in order to form compounds more subservient to it's grand designs, as they are less durable and permanent.

Applications of the Propositions in this Chapter.

The circumstantial history of the combustion of each combustible substance in particular.

The history of soils impregnated with sulphur, and of native sulphuric acid.

The phenomena of natural inflammable gases in quarries, mines, the atmosphere, &c.

The properties of earthy, alkaline, and metallic sulphures.

The

The conversion of sulphures into sulphits and sulphats by the action of air and water.

The properties, extraction, and combinations of phosphorus : metallic phosphures.

The existence of native metallic carbures.

The phenomena depending on the density, weight, ductility, and fusibility of metals.

The properties and uses of alloys.

The formation of secondary ores, from native metallic salts.

Volcanoes, and sulphurous and thermal waters.

Bitumens ; the comparison of sulphur, carbon and simple combustible bodies, with oils, &c., &c.

C H A P. VII.

THE FORMATION AND DECOMPOSITION
OF ACIDS.

I. Since all acids resemble each other in their taste, their manner of giving a red colour to vegetable substances, their tendency to combine with earths, alkalies, and metallic oxyds, and their property of attracting and being attracted powerfully, it was natural to presume, as Newton observed, that they likewise resembled each other in their intimate nature, and possessed some homogeneous principle : and chemical analysis, by the help of the new means it has in its power to employ, has established this as a truth beyond the possibility of doubt.

II. As every acid contains oxygen, and loses its acidity exactly in proportion as it is deprived of this principle, we ought to consider acids as burnt or oxygenated sub-

substances, which are akin to each other from the presence of the acidifying principle.

III. There are two methods of acquiring a knowledge of the nature of acids: one by forming them, by composing them from their constituent parts, in uniting with oxygen such substances as are capable of becoming acid by an union with it: the other, by decomposing them, by *unburning* them, in depriving them of their oxygen by the aid of substances with which this principle has great affinity.

IV. Considered in the last mentioned view, all known acids may be divided into three classes, namely, 1st, those which may be both composed and decomposed, of which our knowledge is most complete: 2dly, those which we can only compose, being incapable of decomposing them; and with these also we are well acquainted: 3dly, those which have never yet been either composed, or decomposed; the nature of which remains altogether unknown.

V. Since, out of thirty known species of acids, as there are but three, strictly speaking, which are in the last predicament, or which we can neither compose nor decompose, so that we are necessarily ignorant of their nature, there is no reason why we should not regard substances of this kind as accurately discriminated, and contemplate their general properties and composition.

VI. All acids being compounds of oxygen with different substances, the former principle is the cause of their resemblance and common properties; the latter, being different in each, may serve to characterize each in particular. For this reason, those matters which are variable in acids are termed their *radicals*, or *acidifiable* principles.

VII. Thus all acids are combinations of radicals, or acidifiable substances, different in each species, with oxygen, which is the same in all: whence it follows, that their common properties, their characters as acids, depend on oxygen; their particular properties,

ties, their specific characters, arise from their radicals.

VIII. The word *acid*, indicating the general and identical nature of these substances, forms their generical name, while the particular name of the radical contained in each may with propriety designate each particular acid. Thus sulphur is the radical of the acid we name *sulphuric*, phosphorus that of the *phosphoric*, carbon that of the *carbonic*, and so on.

IX. Though this nomenclature enjoys the advantage of expressing the nature of each acid, we are unable to employ it for all, because the radicals of some are unknown, and those of others are themselves compounded of several principles, and would consequently require too complicated appellations.

X. Acidifiable radicals may contain different quantities of oxygen, and under this point of view they possess two states of acidity. The first is that, in which they
contain

contain the least possible quantity of oxygen to render them acid. In this their acidity is commonly weak, and they adhere but feebly to the bases with which they are capable of forming salts. The modern methodical nomenclature designates this state of combination and acidity, by giving the names of these weak acids the termination *ous*. Thus we say the sulphurous, nitrous, phosphorous, or acetous acid. The second state of acids is that, in which they contain more oxygen, and in general are completely saturated with it. In this they have all the strength and attraction they are capable of possessing as acids, and the modern nomenclature expresses it by the termination *ic*. Thus we say the sulphuric, nitric, phosphoric, or acetic acid.

XI. With regard to the proportion of oxygen united to acidifiable radicals, still greater latitude may be given to the considerations presented in the foregoing paragraph. Each radical may be contemplated in four states: 1st, containing very little oxygen,

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not

not sufficient to impart to it the nature of an acid, and in this it is nothing more than an oxyd: such is sulphur coloured red or brown, by exposure to the air, and a degree of heat inadequate to produce inflammation; when it is oxyd of sulphur: 2dly, containing more oxygen than in the preceding case, and enough to become an acid, though weak; as in the sulphurous acid: 3dly, possessing still more oxygen than in the second instance, and having acquired powerful acid properties: such is the sulphuric acid: 4thly, conjoined with a larger dose of oxygen than is necessary to constitute a powerful acid, an acid *in ic*; when it is termed an oxygenated acid, or even superoxygenated.

XII. From the considerations above-enumerated it follows, that we have two modes of forming at will acids with different proportions of oxygen. One is, to combine the radicals with such determinate quantities of oxygen as are necessary to convert them into the state required, as is done with sulphur,
phos-

phosphorus, or arsenic: the other to extract from acids containing the greatest possible quantity of oxygen different proportions of this principle, by means of combustible substances which absorb it with great avidity.

XIII. The latter method, founded on the affinity of oxygen for different combustible substances, is frequently employed with success for the complete decomposition of acids, by depriving them of all the oxygen they contain. It is in this way, that acids inflame combustible substances. To produce this effect it is sufficient, that the acids employed do not contain oxygen in a state of solidity, and that the inflammable matter brought into contact with it will absorb it in a more solid state than that in which it subsists in the acid. But these conditions being requisite, inflammation by no means takes place in all decompositions of acids by combustible substances.

XIV. Hot charcoal is successfully used to decompose all acids susceptible of decomposition;
 fition;

fition ; but it is not the only combustible substance, that will answer the purpose ; for most metals, phosphorus, sulphur, and hydrogen in a dry and solid state, as it exists in vegetable compounds, possess the same property.

XV. All the acids, the specific nature of which is owing to their particular radicals, as has been already said, may be divided into four classes, according to the nature of their bases being known or unknown, simple or compound.

A. The first class includes acids with known and simple radicals, or such as are formed by the union of indecomposable combustible substances with oxygen. Its species are the following : sulphuric acid, nitric acid, carbonic acid, phosphoric acid, arsenic acid, tungstenic acid, and molybdenic acid.

B. The second class comprises acids with radicals that are unknown, but strongly suspected of being simple. In it may be

reckoned the muriatic acid, fluoric acid, and boracic acid.

C. In the third class I rank acids with binary compound radicals. Such are all the vegetable acids, the common radical of which is a compound of hydrogen and carbon. In this class the succinic acid should also be placed.

D. To the fourth class belong all acids of which the radicals are at least triple compounds. In this are comprehended the animal acids, the radicals of which are combinations of carbon, hydrogen, and azot.

XVI. Not only is each of the classes in the preceding section distinguishable by general characters inherent in it, but each individual acid also possesses properties, by which it is characterized, and which prevent it's being confounded with any other. And these properties may even be denoted by simple and easy expressions, by phrases similar to those, which naturalists have learnt

learnt from Linné to employ. A sketch of this method will be exhibited in the following sections.

XVII. All acids with simple and known radicals are capable of being decomposed by combustible bodies, which they burn with more or less rapidity, and are thus reduced to their radicals. It is even by means of this decomposition, that the nature of their radicals becomes known. We can also form them from their constituent principles, by uniting their radicals with oxygen.

Acids with unknown radicals, which are suspected of being simple substances from strong analogy, have no other classic character than those of being insusceptible of decomposition by means of combustible substances, and incapable of being formed by art.

Acids with binary radicals, or vegetable acids, are distinguishable by the following characters. 1. They are all decomposable
by

by a strong fire and a sufficient addition of oxygen. 2. In this decomposition they afford water and carbonic acid, formed by the disjunction of their hydrogen and carbon, each of which unites separately with a portion of the oxygen. 3. They are decomposed spontaneously and slowly in a temperature above 53° , if dissolved in water. 4. They cannot be decomposed by any known combustible body, their radical being compounded of two substances which have the strongest attraction for oxygen of any with which we are acquainted. 5. They are convertible into each other; which is owing to the difference between them consisting solely in the proportion of their three constituent principles.

Acids with ternary radicals, and those which are still more compound, or animal acids, though the least known of all, possess some properties which may be deemed classic characters. Such are those of affording ammoniac when decomposed by fire, and furnishing

nishing prussic acid on the proportion of their principles being changed.

XVIII. To these classic characters their specific characters must be added, attempting a language analogous to that of the botanist and zoographer.

Acids of the first class, or with simple and known radicals.

A. Sulphuric acid, formed of sulphur and oxygen by the combustion of sulphur, inodorous, twice as heavy as water, very caustic, less volatile than water, affording sulphurous acid gas and sulphur on being decomposed by red-hot charcoal, metals, &c., and forming sulphats with earths, alkalies, and metallic oxyds.

B. Sulphurous acid, having a powerful smell, very volatile, gaseous, destructive of blue vegetable colours and removing stains produced by these colours on white, gra-

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dually

dually attracting oxygen from the air, and several acids or oxyds, and forming sulphits with earthy or alkaline bases.

C. Nitric acid, liquid, white, caustic, of a strong and nauseous smell, formed of azot and oxygen, inflaming sulphur, charcoal, zinc, tin, and oils, yielding to combustible bodies various portions of oxygen, and thus giving birth to nitrous acid, nitrous gas, or nitrous oxyd, destroying colours, burning and turning yellow vegetable and animal substances, converting them into acids, decomposing ammoniac, produced by putrefying animal matter, forming nitrats with earths and alkalies, remaining slightly united with metallic oxyds, and tending to acidify them.

D. Nitrous acid, the same as nitric acid except in having a smaller portion of oxygen, red or orange coloured in the state of gas, very volatile, depriving vegetables of colour, becoming blue and green on the addition of water, turning yellow nitric acid to which it is united in different proportions, yielding

nitrous gas on the contact of combustible substances, and forming nitrits with earths and alkalies.

E. Carbonic acid, formed of twenty-eight parts of carbon with seventy-two of oxygen, a gas heavier than air and displacing it, filling subterraneous cavities, disengaging itself from liquors in a state of vinous fermentation, extinguishing lighted candles, killing animals, reddening only light vegetable blues, precipitating chalk from lime-water, re-dissolving the chalk in the water, mineralizing acidulous waters, baryt, lime, copper, iron, and lead, in quarries and mines, forming carbonats with earths, alkalies, and metallic oxyds, decomposable by phosphorus alone, and when it is united to alkaline bases, particularly soda in the state of carbonat.

F. Phosphoric acid, composed of phosphorus and oxygen united by rapid and complete combustion, liquid, dense, or solid, vitrifiable by means of fire, dissolving silice in the act of vitrification, decomposable

by carbon which restores it to the state of phosphorus, and forming phosphats with earths, alkalies, and metallic oxyds.

G. Phosphorous acid, differing from the phosphoric only in containing less oxygen, volatile, odorous, eliciting oxygen from various bodies, and forming phosphits with earthy, alkaline, and metallic bases.

H. Arsenic acid, formed of the metal called arsenic and oxygen*, fixed, fusible into a glass, decomposable by means of a large quantity of light and caloric, as well as by several combustible substances, and forming arseniats with earths, alkalies, and metallic oxyds. Oxyd of arsenic, being also capable of uniting with these bases, may be considered as a sort of arsenious acid.

I. Tungstenic acid, composed of the metal called tungsten and oxygen, a white or yel-

* Combustion reduces arsenic to an oxyd only; nitric acid, or oxygenated muriatic acid, adds to this oxyd the quantity of oxygen necessary to convert it into arsenic acid.

lowish powder, fixed, infusible, difficultly soluble, reducible to tungsten by means of *hydrogen*, carbon, &c., forming the native tungstat of lime called *lapis ponderosus*, and the native tungstat of iron, or wolfram of mineralogists.

K. Molybdenic acid, composed of the metal named molybdena and oxygen, of a rough taste, metallic like the two preceding species, in a white powder, becoming blue on the contact of such substances as reduce it, and in consequence of the loss of oxygen returning to the state of molybdena.

Acids of the second class, or with unknown radicals.

XIX. There are three acids, the radicals of which are unknown, though suspected to be simple: the muriatic, fluoric, and boracic.

A. Muriatic acid, gaseous or fluid, of a pungent smell, unalterable by any known combustible substance, on the contrary attracting oxygen from several burnt bodies, particularly from metallic oxyds, and thus becoming *oxygenated muriatic acid*. The oxygenated muriatic acid is remarkable for it's greenish yellow colour, it's action on the organs of animals which it thickens and contracts, it's properties of divesting vegetable substances of colour, burning and inflaming most combustible substances, and forming with potash a salt, which rapidly sets fire to heated inflammable substances, and affords the purest vital air known.

B. Fluoric acid, gaseous, forming a very thick white vapour in the air, corroding glass, dissolving siliceous earth, and forming with this earth a permanent gas, from which water separates a part of the silic.

C. Boracic acid, dry, crystallised in hexagonal laminæ, fusible into a glass, possessing
little

little taste, difficultly soluble, melting with flex, having very feeble affinities, and resigning earthy or alkaline bases to almost all other acids.

Acids of the third class, or with binary radicals.

XX. Acids with binary mixed or compound radicals belong particularly to the vegetable kingdom, and are formed by the union of carbonated hydrogen or hydrogenated carbon with oxygen in different proportions, which accounts, as has already been said, for their reciprocal conversion into each other. These acids being pretty numerous, and capable of becoming still more so by daily discoveries, I have divided them into five genera, in which I have regard to their nature and formation. The first genus includes the pure acids formed in vegetables, reckoning amongst these the succinic acid, which is manifestly of vegetable origin. In this there are five species :

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the

the succinic, citric, gallic, malic, and benzoic acids. The second comprises vegetable acids perfectly formed, but partly saturated with potash. Of these, which are termed acidules, there are two species, the tartarous and oxalic. In the third genus I class the particular acids formed by the agency of the nitric acid, and the precipitation of it's oxygen upon vegetable substances. We have yet but one distinct species in this genus, the camphoric acid; though the oxalic and malic acids are frequently formed by treating vegetable substances with the nitric acid. In the fourth genus I place the acids formed in vegetables treated with fire. Such are the pyromucous, pyroligneous, and pyrotartarous acids. The fifth genus comprehends vegetable acids produced by fermentation, of which we are acquainted with only one, the acetous. The following are the specific characters of the twelve acids here enumerated.

A. Succinic acid, disengaged and sublimed from heated amber, of a strong bituminous

minous smell, oleaginous and inflammable, volatile, crystallizable in the shape of needles, forming permanent crystallizable salts, particularly with metallic oxyds, and adhering more forcibly to the three alkaline earths than to alkalies.

B. Citric acid, crystallizable in rhomboidal laminæ, not convertible into oxalic acid by means of the nitric, having more affinity to earths than to alkalies, and spontaneously decomposable in water and by the action of fire.

C. Gallic acid, abounding in galls, crystallised in little gray or yellowish needles, styptic, precipitating iron black from it's solutions, reducing metallic oxyds united to other acids, and convertible into oxalic acid by means of the nitric.

D. Malic acid, abounding in apples, not crystallizable, convertible into oxalic acid by means of the nitric, and forming at the same time with the malic acid, and even before it, in vegetables treated by the nitric acid.

E. Ben-

E. Benzoic acid, obtained from benzoin, storax, balsam of Peru, vanilla, and cinnamon, by means of heat, crystallizable into compressed prisms, of an aromatic smell when warmed, fusible by a gentle fire, volatile, inflammable, little soluble in water, soluble in the nitric acid, but not decomposable by it.

F. Tartarous acidule, formed of tartarous acid partly saturated with potash, existing in wine, crystallizable, decomposable by fire, affording a considerable quantity of carbonic acid and oil, and leaving behind much carbonat of potash, yielding also on distillation pyrotartarous acid, little soluble, decomposable in water, forming triple salts with alkalies and metallic oxyds, and becoming very soluble by the addition of borax or boracic acid. The tartarous acid, obtained from the acidule, is crystallizable in needles interwoven amongst each other, unalterable in the air, very soluble, forming anew the acidule by the addition of a little potash, decomposing the sulphats, nitrats, and

and muriats of potash and soda, till they reciprocally form acidules, and convertible into oxalic acid by means of the nitric.

G. Oxalic acidule, formed of oxalic acid partly saturated with potash, extracted from the juice of sorrel, crystallized in parallelopipeds, little decomposable by fire, affording no oil, little soluble, and forming triple salts with earths and alkalies. The oxalic acid extracted from it is very soluble, and very crystallizable, attracts lime from all other acids, perfectly resembles that which is formed from all vegetable substances by the contact of nitric acid, and is the least decomposable and most oxygenated of the vegetable acids.

H. Camphoric acid, produced by distilling camphor with nitric acid, crystallizable in parallelopipeds, forming perfectly crystallizable salts with earths and alkalies, and not attracting lime from all the other acids as oxalic acid does. This acid is very little known.

I. Py-

I. Pyrotartarous acid, a modification of the tartarous acid produced by fire, of an empyreumatic smell, and burnt colour, very rarefiable and swelling up greatly with caloric, not crystallizable, and forming with earthy and alkaline bases salts different from those afforded by the tartarous acid. With this acid we are but little acquainted.

K. Pyromucous acid, formed by the distillation of gums, sugar, or feculæ, possessing very powerfully the agreeable smell of a lozenge, volatile, colouring vegetable and animal substances red, and decomposable by a strong fire. This also is little known.

L. Pyroligneous acid, extracted from wood by distillation, of a pungent fetid smell, not crystallizable, decomposable by a strong fire, volatile, forming peculiar salts with earths, alkalies, and metallic oxyds, and having particular attractions for these bases, but in other respects we are as little acquainted with it as with the two preceding acids.

M. Acetous

M. Acetous acid, formed by the fermentation of wine, on which account it is called vinegar, of an agreeable smell and taste, volatile and liquid, decomposable by a strong fire, capable of being furcharged with oxygen when distilled with metallic oxyds, and thus becoming acetic acid, or radical vinegar, which is more acrid and odorous than the acetous acid, inflammable, and mixed with alcohol,

Acids of the fourth class, or with ternary radicals.

XXI. Acids with ternary compound radicals, which were spoken of above as formed in general of carbon, hydrogen, and azot, united with oxygen, appertain more especially to animal substances. With these we are still less acquainted than with the preceding acids: but recalling here to the reader's mind, that they all furnish ammoniac on being decomposed by the action of fire, and prussic acid on a change in the proportion of their principles, I shall remark, that the prussic acid seems to be to these
acids

acids in general what the oxalic is to vegetable acids, and add, that on converting animal substances into oxalic acid by the agency of nitric acid, prussic acid is constantly formed during the operation, and evolved in the state of vapour.

There are seven animal acids known, all of which appear to belong to this class of compounds, namely, the lactic, saccholactic, sebatic, lithic, formic, bombic, and prussic acids. In each let us seek for a few characteristic properties.

A. Lactic acid, formed, with a little acetic acid, in milk spontaneously soured, not crystallizable, soluble in alcohol, affording on distillation an acid analogous to the pyrotartarous, forming deliquescent salts with earthy and alkaline bases, and decomposing alkaline acetates.

B. Saccholactic acid, precipitating as a white powder from oxalic acid formed by sugar of milk and nitric acid, little sapid,
scarcely

scarcely at all soluble, decomposable by fire, when a salt resembling benzoin in smell sublimes from it, and forming crystallizable salts with alkalies. This is very little known.

C. Sebatic acid, obtained from fat by the action of fire, separated from it also by alkalies and lime with the assistance of a strong heat, liquid, white, smoking, very acrid in taste and smell, forming crystallizable and fixed salts with earth and the alkalies, decomposing muriatic of mercury, and decomposable by a strong heat.

D. Lithic acid, existing in human urine, forming the stone in the bladder, dry, crystallized in flat needles, almost insipid and insoluble, in part volatile, decomposable by a strong heat, affording ammoniacal carbonate and prussic acid by the agency of fire, forming a beautiful red solution with nitric acid, soluble in caustic alkalies, and precipitating of a gridelin or reddish colour from the urine of persons labouring under fever.

E. For-

E. Formic acid, obtained from ants by distillation or expression with water, reddening blue flowers while in the living insect, flying off in a very highly odorous vapour, in smell analogous to musk, killing animals in this form of gas, capable of being employed for the same domestic purposes as vinegar, decomposable by a strong fire, taking oxygen from oxygenated muriatic acid, frequently stronger than sulphuric acid, and forming crystallizable and not deliquescent salts with earths and alkalies.

F. Bombic acid, contained in a reservoir near the anus of the chrysalis of the silkworm, extracted from this reservoir either by expression or by means of alcohol, mingled with a brown oil and a gum while in the worm, liquid, of an amber yellow colour, decomposable spontaneously, and affording prussic acid by means of distillation and nitric acid. In its combinations it is unknown.

G. Prussic

G. Prussic acid, saturating iron and colouring it in prussian blue, obtained at present by the distillation of blood, or the action of nitric acid on albumen, gluten, animal fibre, &c., and disengaged in proportion as oxalic acid is formed, remarkable for a noxious fetid smell analogous to that of bitter almonds, very decomposable by a strong fire and then affording ammoniac, susceptible of the form of gas, taking metallic oxyds from a great number of other acids, capable of being artificially formed by the union of hydrogen, carbon, azot, and oxygen, little acid in it's taste, and containing, as far as appears, very little oxygen.

XXII. It follows from what has been advanced in the preceding sections, that if acids be divided into two classes, distinguished by having simple or compound radicals, they will be found to differ principally in this circumstance, that those with simple radicals are not convertible into each other, because the properties of one simple radical, sulphur for example, vary much from those

H of

of another, such as phosphorus, whence it would be necessary to begin with converting these radicals into each other, which is far beyond the power of art: the acids of the other class, on the contrary, being formed in general of a base composed of hydrogen, carbon, and azot, united with oxygen, appear to differ from each other only in the proportions of the two or three principles which enter into the composition of their radicals, and of the oxygen united with these, have a tendency to undergo incessant changes in their composition, especially from variation of temperature, humidity, &c. and spontaneously pass into different states. Thus from the mere efforts of vegetation plants contain different acids at different periods of their growth: and thus solutions of vegetable acids in water change, alter their nature, and ultimately yield a certain quantity of carbonic acid and water, as they arrive at the last stage of decomposition.

XXIII. If we attend to these facts, it is easy to perceive, that there still remain to be
discovered

discovered not only the nature of several acids, with the composition of which we are unacquainted, but also perhaps a considerable number of new acids, in plants and animals. For among the productions of these organized beings, the principles of which we have only begun to investigate, we are far from having exhausted all the possible combinations of carbon, hydrogen, azot, and oxygen, as the most superficial calculation will demonstrate. To this order of investigation and discovery we must refer the examination of the acids indicated in cork, gray-pease, and several other vegetable matters, as well as those of the gastric juice, the coagulum of the blood, *cruoric acid*, &c. It will be perceived too, from the succeeding chapter, that most burnt metals seem to enter into the class of acids, and comport themselves as these salts in a great number of combinations: so that acids appear to be the most numerous of all bodies, and perform the principal parts in the chemical alterations, which both simple and compound substances are destined incessantly to undergo.

Application of the Propositions respecting acids.

The artificial formation of sulphuric acid,
by the combustion of sulphur in the great.

The discharging of colour from white linens
and stuffs by means of the sulphurous
acid.

The new art of bleaching by means of the
oxygenated muriatic acid.

The theory of the *aqua regia* of the an-
cient chemists.

The art of engraving on glass by the
fluoric acid.

One part of the theory of the formation of
artificial nitre-pits.

The existence and formation of the known
native acids.

The influence of acids in mineralization.

The extraction and purification of vegeta-
ble acids and acidules.

The

The spontaneous formation and destruction
of vegetable acids.

Their reciprocal conversion into each other
by vegetation, fermentation, &c.

C H A P. VIII.

OF THE UNION OF ACIDS WITH EARTHS
AND ALKALIES.

I. ALL acids unite with alkalies and the alkaline earths without being decomposed. The combinations thus formed have been called neutral, middle, compound, or secondary salts. To the first two of these names they have no claim, unless when they are neither acid nor alkaline: the other two are more accurate, and of greater utility. All these salts are readily made by art; and nature exhibits a considerable number of them, particularly of those the radicals of which are simple. Mineralogy is continually making new acquisitions in this branch of knowledge, by the analysis of minerals, which alone is capable of unfolding to us their intimate nature.

II. Every

II. Every compound salt ought to have a double name, one branch of which should indicate it's acid, the other it's earthy or alkaline base. The former has two different terminations announcing the state of the acid. Words ending in *at* are employed when the salt contains an acid saturated with oxygen, which is denoted by the termination *ic* : thus *nitrats* are formed by the *nitric* acid : and words ending in *it* imply feeble acids, not saturated with oxygen, for which, as has been already observed, we use the termination *ous* : thus the compounds of the *nitrous* acid are *nitrits*.

III. As there are thirty-four kinds of acids known, and seven earthy or alkaline bases, which may be united to form compound salts, the number of these salts might be estimated at two hundred and thirty-eight : but such a calculation would be far from exact : for, 1st, there are only few acids capable of combining with silice : 2dly, there are others which cannot unite with certain earthy bases on account of their

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weakness,

weakness, or with ammoniac without decomposing it: 3dly, there are several acids which may be united to the same bases in three ways, or remain at three different points of saturation with these bases, namely with excess of acid, with excess of base, and exactly neutralized. Thus we are far from being able to determine with accuracy the number of earthy and alkaline compound salts, because we are far from having sufficiently examined all these combinations to attain a perfect knowledge of them, and assure ourselves whether they be not susceptible of several degrees of saturation, &c.

IV. All the acids possessing different elective attractions or affinities for each alkaline or earthy base, it is necessary to be fully acquainted with the whole of these respective affinities, before we can have a complete history of compound salts: and as a very few only of these affinities have yet been determined with accuracy, we are far from possessing the general mass of facts that relate to this order of bodies. Indeed

one tenth of these combinations has not yet been duly investigated.

V. To begin the history of compound salts methodically, we must divide them into genera and species, and fix their generic and specific characters. As this branch of the subject has not yet occupied the attention of chemists, a slight sketch of it is all that can be given; though in the present state of science it is essential to employ the method of botanists in the enunciation of chemical properties.

There are two methods of dividing compound salts, to which recourse might be had; the one founded on their acids, the other on their bases: at present, however, it is from the acids only we can establish genera comprehending the whole of these salts, for they alone are capable of furnishing generic characters; the influence of the bases on the properties of these compounds not being sufficiently known, to enable us to consider these earthy and alkaline substances as the heads of the generical divisions.

VI. Thus

VI. Thus we may reckon thirty-five genera of compound salts according to the number of the acids; and the generical names being taken from their acids, we have for these thirty-five genera the following denominations :—

Genus I,	SULPHATS.
Genus II,	SULPHITS.
Genus III,	NITRATS.
Genus IV,	NITRITS.
Genus V,	CARBONATS.
Genus VI,	PHOSPHATS.
Genus VII,	PHOSPHITS.
Genus VIII,	ARSENIATS.
Genus IX,	ARSENITS.
Genus X,	TUNGSTATS.
Genus XI,	MOLYBDATS.
Genus XII,	MURIATS.
Genus XIII,	OXYGENATED MU-
	RIATS.
Genus XIV,	FLUATS.
Genus XV,	BORATS.
Genus XVI,	SUCCINATS.
Genus XVII,	CITRATS.

Genus

Genus XVIII,	GALLATS.
Genus XIX,	MALATS.
Genus XX,	BENZOATS.
Genus XXI,	TARTRITS.
Genus XXII,	OXALATS.
Genus XXIII,	CAMPHORATS.
Genus XXIV,	PYROMUCITS.
Genus XXV,	PYROLIGNITS.
Genus XXVI,	PYROTARTRITS.
Genus XXVII,	ACETATS.
Genus XXVIII,	ACETITS.
Genus XXIX,	LACTATS.
Genus XXX,	SACCHOLATS.
Genus XXXI,	SEBATS.
Genus XXXII,	LITHIATS.
Genus XXXIII,	FORMIATS.
Genus XXXIV,	BOMBIATS.
Genus XXXV,	PRUSSIATS.

VII. Each of the thirty-five genera of compound salts above enumerated should be considered with respect to it's discriminative characters, or those qualities which are sufficient to distinguish it, and give an accurate idea of it's difference from all others. For
this

this purpose, out of the properties displayed by it, one, if possible, or at most two or three, should be selected, of prominent features, and constituting an essential character of each genus. I shall now attempt a sketch of this sort.

Genus I, SULPHATS : decomposable by charcoal, &c., into sulphures.

Genus II, SULPHITS : yielding the smell of burning sulphur on the contact of almost all acids, with effervescence.

Genus III, NITRATS : accending combustible bodies at different temperatures, and almost all of them reducible to their bases by the action of fire.

Genus IV, NITRITS : decomposable by weak acids, which separate from it red nitrous vapour.

Genus V, CARBONATS : leaving the characters of their bases more or less prominent ;

ment ; and producing with all acids a brisk and sensible effervescence, till their carbonic acid is completely evolved.

Genus VI, PHOSPHATES: decomposable, mediately or immediately, by charcoal, which separates from them the phosphorus.

Genus VII, PHOSPHITES: all decomposable immediately by charcoal, which separates from them the phosphorus ; and emitting vapours on the contact of sulphuric acid, &c.

Genus VIII, ARSENIATES: affording on the contact of red hot charcoal the smell and white vapour of arsenic ; and not decomposable by acids alone, unassisted by a double affinity.

Genus IX, ARSENITES: the arsenious acid is separated and precipitated from their solutions, by the contact of all the acids, even of the arsenic acid.

Genus

Genus X, TUNGSTATS: turning yellow on the addition of nitric or muriatic acid.

Genus XI, MOLYBDATS: not yet distinguishable till the molybdenic acid is separated from them by other acids, and in consequence of the characters exhibited by the molybdenic acid.

Genus XII, MURIATS: affording muriatic acid by means of concentrated sulphuric acid, and oxygenated muriatic acid when acted upon by the nitric.

Genus XIII, OXYGENATED MURIATS: accending all combustible bodies at a lower temperature than they are kindled by nitrats, with a more vivid flame, and remaining in the state of muriats after the combustion is ended.

Genus XIV, FLUATS: yielding a vapour that corrodes glass, on the contact of concentrated sulphuric acid.

Genus

(III)

Genus XV, BORATS : fusible, with or without separation of their bases ; and affording, when another acid is united with their solution, boracic acid in foliated crystals.

Genus XVI, SUCCINATS : these are not to be known, or characterised, but by decomposing them, and observing their acid : most of them retain the smell of burnt amber.

Genus XVII, CITRATS : not sufficiently known for us to find in them generic characters : to distinguish them, the citric acid must be separated by the most powerful mineral acids.

Genus XVIII, GALLATS : all strongly characterized by their property of precipitating iron black from it's solutions, and partly reducing the oxyds of silver, gold, and mercury, in separating them from the menstrua in which they are dissolved.

Genus

Genus XIX, MALATS : almost all deliquescent : not to be known but by obtaining their acid separately by the aid of mineral acids.

Genus XX, BENZOATS : ascertainable on discerning the smell of the benzoic acid, separated by acids of greater power.

Genus XXI, TARTRITS : sufficiently striking characteristics for distinguishing these are to be found in their tendency to compose triple salts, and acidules less soluble than either the pure acid, or the neutral salts which the tartarous acid forms with the same bases.

Genus XXII, OXALATS : may be characterized by their tendency to form acidules of difficult solution, and their property of decomposing all calcareous salts.

Genus XXIII, CAMPHORATS : too little known to have generic characters assigned them : they are to be distinguished by the presence

presence of the camphoric acid, and the recognition of it's properties when separated.

Genus XXIV, PYROMUCITS: similarly circumstanced with camphorats.

Genus XXV, PYROLIGNITS: the same may be said of these.

Genus XXVI, PYROTARTRITS: these rank with the three preceding genera.

Genus XXVII, ACETATS: yet too little distinguished from acetits: evolving, when decomposed by mineral acid, a very strong and pungent white vapour.

Genus XXVIII, ACETITS: all recognizable by their acid disengaged by means of sharper acids.

Genus XXIX, LACTATS: very little known: their acid, separated by others, can alone characterize them.

Genus XXX, SACCHOLATS: as the lactats: unknown.

Genus XXXI, SEBATS: emitting the white vapour and acrid smell of sebacic acid on the contact of the strongest mineral acids.

Genus XXXII, LITHIATS: the weakest of all salts in their attractions, being decomposable even by the carbonic acid.

Genus XXXIII, FORMIATS: very little known, and recognizable only by means of their acid.

Genus XXXIV, BOMBIATS: similarly circumstanced with the formiats.

Genus XXXV, PRUSSIATS: completely characterized by their property of forming prussian blue with solutions of iron.

VIII. To determine the specific characters of nearly two hundred and forty-five
species

species contained in these thirty-five genera, they would require to be profoundly studied, and in this respect science is yet little advanced. While our knowledge is thus defective, it is of importance to indicate at least the path we ought to pursue to complete the history of these compounds, and to ascertain with precision the method of investigating their properties.

Each compound earthy or alkaline salt presents to our observation,

1st, Figure, and the varieties of that figure. This ought to be described geometrically: the inclination and degrees of it's angles, the primitive formation of the crystals, the interior form, their dissection, and the laws of decrease which determine their varieties, should be detailed.

2dly, It's existence by art or nature, with a comparison of the native and artificial salt.

3dly, Taste.

4thly, The action of fire ; whether it be null, fusing, vitrifying, subliming, or decomposing, &c.

5thly, That of light.

6thly, The influence of the air ; whether it be null, or impart water to the crystals, or elicit water from them.

7thly, The union with water, the quantity necessary to dissolution at different temperatures, the caloric absorbed or evolved, the crystallization produced by refrigeration or evaporation.

8thly, The attraction of earths which modify the salt, decompose it, produce no change in it, or unite with it to form a triple salt.

9thly, The effect of alkalies on it ; whether null, decomposing, or sometimes com-

combining with it so that a triple salt is formed.

10thly, The comparative action of acids different from that which it contains, decomposing the salt, changing it's nature, or producing in it no alteration.

11thly, The operation of other neutral salts on it; which may produce a complete union, forming a triple salt; a double decomposition, by an interchange of acids and bases; a precipitation, in consequence of their attraction for water; or no alteration whatever.

12thly, The dissolubility or indissolubility of the salt in alcohol.

13thly, It's alterability or unalterability by means of charcoal, which may decompose it's acid, or leave it untouched.

14thly, The influence of vegetation and fermentation on the salt.

15thly, and finally, it's action on the animal economy.

IX. If all these questions were answered with precision, in the present state of chemistry, the history of earthy and alkaline compound salts would not only be complete, but would throw considerable light on various phenomena of nature and art, which still remain plunged in great obscurity.

X. Some saline combinations of an acid with two bases, particularly magnesia and ammoniac, are already known: these compounds bear the name of *trisules*, or triple salts; but a far greater number exists, of which we are not sufficiently aware, and which demand all the attention that can be paid them by chemists. The earth conceals, both at it's surface and in it's superficial cavities, saline compounds differing from those which art produces by the simultaneous existence of two bases, or even of two acids: borat of lime and borat of magnesia have already been found crystallized
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together in cubic quartz, phosphat of lime and fluat of lime in the earth of Marmaroch and the Estremadura stone, &c.

Applications of the propositions in this chapter.

The knowledge of native salts.

The crySTALLIZATION and purification of useful salts.

The phenomena of solutions.

The precipitation and preparation of alumin, magnesia, &c.

The attraction of lime, potash, soda, and ammoniac for acids.

The formation of neutral salts by nature.

All the details of halotechny.

The preparation of the nitric, muriatic, boracic, and several other acids.

C H A P. IX.

THE OXYDATION AND DISSOLUTION OF
METALS.

I. METALS have already come under consideration in the sixth chapter as indecomposable or single combustible bodies, and been characterized by their most striking properties. But these general observations are not sufficient : the important parts performed by these substances, in the phenomena of nature and the processes of the arts, require, that they should be separately examined, and with sufficient minuteness to enable us to appreciate the whole of their influence.

II. Though metals are capable of uniting in their metallic state with each other, with sulphur, with phosphorus, with carbon, and with combustible substances in general, it is
much

much more common to see them combined with oxygen previous to their union with other bodies ; or, in other words, for them to enter into the greater number of compounds of which they constitute a part, it is necessary, that they first unite with oxygen, or be converted into the state of burnt bodies. Accordingly, all the singular phenomena displayed by metals in their combinations, and the changes of form they undergo, are owing to their attraction for oxygen, and the different proportions in which they contain this principle.

III. Though there are various circumstances under which metals may be united with oxygen, they may be reduced in general to three. The first is the contact of air, assisted by caloric ; the second is owing to the decomposition of water ; the third, to that of acids. In this triple view the oxidation and dissolution of metals are here to be considered.

IV. All

IV. All metals heated in the air, and raised to a temperature more or less high, are susceptible of burning with a vivid flame, great heat, and a true deflagration, either previous or subsequent to their entering into fusion : thus they absorb oxygen in a state of greater or less solidity : those which oxydate slowly, and without perceptible inflammation, equally disengage light and caloric from the vital air, but in so small a quantity at a time, that they are not rendered sensible to our organs.

V. Elevation of temperature favours the absorption of the oxygen of the atmosphere by metals, and renders the combination of this principle with these combustible bodies more solid.

VI. While there are some metals which never burn in the air, except at a very high temperature, as gold, silver, and platina, there are others which burn at all temperatures, even the lowest, and with great promptitude ; as manganese, which oxy-
dates,

dates, and falls into powder, in a few hours, on the contact of air several degrees below the freezing point. Some, as iron, copper, lead, &c., burn slowly, and in the course of some months, in the air, even though cold.

VII. All metals increase their weight during this operation, which does not take place without the contact of air, and consequently absorb a principle, the oxygen of the atmosphere, without losing any one. Neither the name of calcination, which was given to this phenomenon, nor that of metallic calces, can be retained ; but instead of these have been substituted the terms of combustion and oxydation for the operation, and of metallic oxyds to denote the metals thus burnt.

VIII. The colours which metals display in burning, or with which their flame is tinged, appear to be owing to the dissolution of the metallic molecules in the light that is evolved.

evolved. Thus copper yields a green flame, &c.

IX. Not only do all metals compared with each other absorb different quantities of oxygen to saturate them in their combustion by the contact of air, but each metal considered separately absorbs different proportions, and stops at various points of oxydation, according to the degree of temperature to which it is raised. Thus tin, lead, copper, iron, change colour and assume the tints of the rainbow, at the first degree of fire to which they are exposed in contact with the air: lead first becomes a gray oxyd, next yellow, and lastly red: mercury passes from black to white, from white to yellow, and from yellow to red: iron, at first a black oxyd, becomes next green, then brown, and ultimately white: copper is at first a brown oxyd, from which it changes to blue, and it's last degree of oxydation imparts to it a green colour.

X. All

X. All metals differ in their attraction for oxygen. From some, as gold, silver, &c., oxygen is elicited by means of light almost alone, or assisted with a very small portion of caloric; others, as mercury, require for it's separation a great degree of fire, and much light; while the greater number do not part with this principle, merely by the intervention of light and caloric. To decompose oxyds of the last description, they must be heated with charcoal, which attracts from them their oxygen.

XI. It is owing to this diversity of attractive power for oxygen, that some metals are deprived of it by others, as silver and gold are by almost all the rest, mercury by copper, copper by iron, &c. We are not yet perfectly acquainted with all these degrees of attraction, but the present state of our knowledge indicates the following order of the metals, beginning with that of which the attraction for oxygen is most powerful: manganese, zinc, iron, tin, copper, mercury, silver, gold.

XII. Va-

XII. Various metals decompose water, and this the more sensibly and rapidly the higher their temperature is raised, because then the abundant quantity of caloric employed more forcibly attracts and dissolves the hydrogen. Thus iron decomposes water with great rapidity when it is of a white heat, though it requires a considerable time to effect its decomposition at the highest temperature our atmosphere ever attains.

XIII. Iron, zinc, tin, and antimony, appear to be capable of decomposing water : it is probable, too, that manganese, and even some other metallic substances, are equally capable of effecting this purpose. This decomposition is attributable to a stronger attraction for oxygen, than hydrogen possesses : whence it follows, that hydrogen completely decomposes the oxyds of those which do not decompose water. But it is requisite here to distinguish the different degrees of oxydation : for the oxyd of iron highly oxydated, or oxydated brown, is partly decomposed by hydrogen, and reverts to the state of black oxyd,

oxyd, because iron is capable of eliciting oxygen from water only to that degree which oxydates it black, and beyond this degree of oxydation decomposes it no longer.

XIV. All metals capable of decomposing water effect this operation with more ease and rapidity, when assisted by the contact of a substance which has a great tendency to unite with their oxyds. Frequently even metals, like other combustible bodies, which alone would not decompose water, are rendered capable of it by the presence of some other substance, which acts by a predisponent affinity. Thus almost all metals are enabled to effect the decomposition of water by means of acids.

XV. Metallic oxyds have this peculiarity in their combinations, that they seem, with regard to acids, to perform the functions of alkalies, or earthy and alkaline bases; though, on the other hand, they are capable of uniting with earths and alkalies, as if they
were

were a sort of acids. Of the latter, indeed, there are fewer than the former; and it is observable, that they which saturate alkalies in the manner of acids are in general those to which oxygen most powerfully adheres, as antimony, lead, iron, and manganese. It has already been said, in Chapter VI, that there are three metals which are truly acidifiable.

XVI. Metals cannot be dissolved by acids without being previously oxydated: for this reason, such metallic oxyds as are soluble in acids dissolve in them slowly, and without effervescence; while metals themselves cannot be dissolved in the same menstruum, without motion and effervescence being produced.

XVII. The effervescence occasioned by the dissolution of metals arises from this, that, in absorbing oxygen, they take it from a principle, which assumes the form of gas, or elastic fluid. This principle proceeds either from the water, or from the acid, employed in the process, according as the one

or the other is decomposed ; and sometimes it originates from both, when both are decomposed at the same time by the metal.

XVIII. Sulphuric acid thus decomposed by metals, when in a concentrated state, gives out sulphurous gas ; and nitric acid, nitrous gas.

XIX. Sulphuric acid diluted with water, greatly facilitating the decomposition of the aqueous fluid by means of metals, evolves in this process hydrogen gas : this is eminently the case in the dissolution of iron or zinc by dilute sulphuric acid. The phosphoric acid acts nearly in the same manner as the sulphuric with metals.

XX. Nitric acid is not only decomposed by several metals, but also admits the decomposition of water at the same time. For this it suffices, that the metal dissolved in it be extremely greedy of oxygen : such is particularly tin. In this case, the hydrogen of the water, uniting with the azot of

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the nitric acid, forms ammoniac ; for which reason, these solutions afford no gas, and contain ammoniacal nitrat. Hence we understand how most solutions of the white metals in nitric acid evolve ammoniacal vapours in the injection of quicklime.

XXI. The muriatic acid, as it is incapable of being decomposed by combustible bodies, of itself dissolves few metallic substances. It attacks only such metals as possess sufficient avidity for oxygen to decompose water : accordingly, during the dissolution of metals in the muriatic acid hydrogen gas is always evolved.

XXII. Not only is the muriatic acid incapable of being decomposed by metals, but it also possesses the property of attracting oxygen from most metallic oxyds : in doing which it passes to the state of oxygenated muriatic acid. To this strong affinity for oxygen the muriatic acid owes it's property of easily dissolving metallic oxyds, on which account it is employed with success for dissolving

dissolving the oxyd of iron, which other acids are unable to attack. If metallic oxyds be furcharged with oxygen when we dissolve them in muriatic acid, an effervescence arises, because a part of the acid flies off in the form of oxygenated muriatic acid gas. If the oxyds be only at the proper point of oxydation for uniting with this acid, they dissolve in it without any movement or effervescence, as salt or sugar will in water.

XXIII. The boracic and fluoric acids unite but feebly with metallic oxyds: they do not dissolve pure metals, because they are not decomposable by them; but they enable water to oxydate such of them as have most affinity for oxygen. It is the same with the carbonic acid, which unites well with most metallic oxyds, and is often found combined with them in their native state.

XXIV. Metallic acids are easily decomposed by very combustible metals: they unite very perfectly with their oxyds, and are frequently

quently found thus combined in a native state.

XXV. Acids of the vegetable and animal kind, or of which the radicals are formed by hydrogen and carbon, are not decomposed by metals; but they render water extremely decomposable by them, and unite with metallic oxyds with considerable solidity. Many of them occasion these oxyds to revert to the metallic state.

XXVI. The oxyds of metals cannot unite with acids, and still less remain combined with them, unless they contain certain proportions of oxygen: if they have less than the determinate quantity, no union will take place; if more, they will separate from them.

XXVII. Beside this general truth, there is another of the same kind peculiar to each acid and each metal; which is, that they cannot remain reciprocally united, but within certain limits of oxydation, and these oftentimes

oftentimes very confined. There is a determinate proportion of oxygen in the combination of an acid with a metallic oxyd.

XXVIII. It is in consequence of this law, that metallic solutions exposed to the air grow turbid, and form a precipitate, in proportion as the metallic oxyd, by absorbing oxygen from the atmosphere, becomes gradually insoluble in the acid. This is the reason of the decomposition, which the atmosphere effects on most metallic sulphats and nitrats.

XXIX. It even frequently happens, that metallic oxyds dissolved in acids react by degrees on these salts, and take from them, though in close vessels and without the contact of air, a portion of their oxygen, so that they soon separate, and are precipitated to the bottom of the solution.

XXX. Heat is eminently favourable to this successive decomposition of acids by metallic oxyds. Thus nitric solutions, when K_3 heated,

heated, grow turbid, or become more and more decomposable by air and water, which is particularly remarkable in the nitric solution of mercury.

XXXI. There are metals which have so great tendency to oxydate themselves with acids, that they cannot remain united, or form permanent solutions with them. This is particularly the case with those, which have the property of becoming acids, or forming oxyds capable of combining with alkalies; as arsenic, tungsten, molybdena, antimony, tin, iron, &c. accordingly we find the solutions of these metals, especially in the nitric acid, are always loaded with precipitates, and contain little or no metallic oxyd.

XXXII. From what has been said it appears, that, to form metallic salts, the oxyds of metals must remain united with acids, and have no tendency to separate from them. It is requisite too, that we do not augment their
affinity

affinity for oxygen, or bring them into contact with this principle.

XXXIII. Metallic compound salts have always, or almost always, an excess of acid : all of them likewise are more or less acrid or corrosive, which shows a tendency to become acid in most metallic oxyds.

XXXIV. Those properties of metallic salts with which it is of importance to be acquainted may be included under the following heads.

1. Figure, and it's varieties : 2, sapidity or causticity, more or less powerful : 3, alteration by means of light : 4, fusion, desiccation, decomposition, by means of caloric, more or less marked : 5, deliquescence, efflorescence, or decomposition, more or less complete, by the action of the air : 6, solubility in water, warm or cold ; decomposition more or less promoted by pure water ; &c. : 7, decomposition by earths and alkalies ; nature of the metallic oxyds precipitated ; complete

K 4 precipitation,

precipitation, or formation of triple salts, partly alkaline or earthy, partly metallic : 8, alteration of the metallic oxyds precipitated, at the instant of their precipitation, either by the air, or by the nature of the alkali employed for the precipitation, as happens when ammoniac is used : 9, reciprocal alteration by different acids ; decomposition taking place, or not ; affinity of acids for the metallic oxyds ; changes of the oxyds discoverable by their colour : 10, alteration by earthy or alkaline neutral salts, whether exhibiting an union without decomposition, or a double decomposition : 11, reciprocal action of metallic salts on each other, announcing either simple union, a simple change of bases by the acids, or a displacement of oxygen precipitating both the oxyds, one because it is partly disoxydated, the other because it is superoxydated, as is the case, for example, in the useful precipitation of the muriatic solution of gold by the muriatic solution of tin, which furnishes the purple precipitate of Cassius : 12, union with earthy or alkaline

2 fulphures ;

sulphures ; the formation of a kind of sulphurous ores.

XXXV. Metallic oxyds have different degrees of affinity with acids, and some may be employed to decompose combinations of others. But the different affinities of metals for oxygen are the most important cause of the phenomenon of the precipitation of metallic solutions. Thus several metals, by taking oxygen from others dissolved in acids, occasion their reappearance in the metallic form ; as mercury does with silver, copper with mercury, iron with copper, zinc with iron, &c. Sometimes metals do not deprive metallic oxyds dissolved in acids of all their oxygen ; which occurs when the precipitating metal has no occasion for all the oxygen of the metal dissolved, to assume it's place in the acid : Thus tin, when it precipitates the oxyd of gold, does not elicit from it all the oxygen it contains, but suffers it to precipitate in a peculiar state of oxydation. Metallic oxyds, in dividing oxygen among them in
new

new proportions, precipitate with properties which deserve to be more accurately investigated than has hitherto been done.

Application of what has been said in this Chapter.

The preparation of all the metallic oxyds useful in the arts.

Coloured glass, enamels.

Metallic salts of use in the arts.

The effects of these salts in the arts in which they are employed.

The solution and parting of metals.

The precipitation of metallic oxyds by alkalies and earth.

These applications are in general so useful and multifarious, that they cannot be exhibited unless in the particular history of each metal.

C H A P. X.

THE FORMATION AND NATURE OF VE-
GETABLE SUBSTANCES.

I. THE substances which constitute the texture of vegetables differ from mineral substances in this, that they are of a more complex order of composition, and though all are extremely susceptible of decomposition or analysis, not one is an object of synthesis.

II. Nothing but the texture of living vegetables, nothing but their vegetating organs, can form the matters extracted from them ; and no instrument invented by art can imitate the compositions, which are formed in the organic machines of plants.

III. Though vegetables form all the materials which constitute their texture with
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four or five natural substances, caloric, light, water, air, and the carbon derived from some remains of plants decayed into mould, we find an extreme variety in the properties of these materials. These may be reduced, however, to a certain number of principal heads, under the name of *immediate materials of plants*, because they are obtained from them by simple processes, almost wholly mechanical, by a sort of direct analysis, which does not alter their nature.

IV. These matters, which are more or less compound, are placed in particular organs, vessels, distinct cells, &c. Sometimes their seat is in the root, or stalk, bark, and leaves, at the same time: at others they are contained only in the flowers, fruits, or seeds, and even in certain parts of these organs. This particular situation of the immediate materials indicates the different organization of the texture of the part, as the cause of the various nature displayed by each of them.

V. The

V. The different place occupied by each of these materials of vegetables often enables us to obtain them easily separate and pure. It is sufficient, when this local distribution occurs, to bruise and open the vessels or cells which contain them, and express their liquid juices. Nature herself frequently exhibits this separation at the surfaces of plants, even by the power of vegetation: thus the sap, manna, gum, resin, &c. spontaneously flow: though art is often obliged to separate from each other several of these materials united and confounded together. The means it employs for this purpose are usually simple and easily practised: such as rest, filtration, expression, ablution, and distillation with a gentle heat, which produce no alteration in the substances subjected to these processes.

VI. Among the materials of vegetable bodies obtainable by simple means, which change not their nature, may be reckoned the following substances, either fluid or solid:

I. The

1. The extractive matter, or extract :
2. Mucus, or mucilage :
3. Sugar :
4. Essential salts :
5. Fixed oil :
6. Volatile oil :
7. Aroma :
8. Camphor :
9. Resin :
10. Balsam :
11. Gum-resin :
12. Fecula :
13. Gluten :
14. Colouring matter :
15. Elastic gum :
16. The ligneous part.

Beside these sixteen principles, a substance analogous to animal albumen has been discovered in the analysis of vegetables ; and it is probable, that some other unknown vegetable principles exist, as the matter proper for tanning hides, or *tannin*, &c.

VII. It is necessary here to be fully aware, that, on reducing all the facts of vegetable analysis to general terms, or leading results, nothing more has been found in any of the plants hitherto examined, than the eighteen substances abovementioned ; so that we may affirm, that they actually compose the texture of all known vegetables, and that a very accurate analysis is made of a vegetable, when we separate these from it. Yet it is not to be understood, that all these eighteen immediate materials are to be found in the different parts of vegetables, or even in each vegetable taken all together. There are plants, all the parts of which do not furnish so many as five or six of these materials : others contain eight or ten : some afford them all. But supposing we could mingle and blend together even chemically all the plants which have ever occupied the attention of the chemist, this mixture, this combination, confused in appearance, would exhibit only the sixteen or eighteen abovementioned substances, as the results of the most accurate and refined analysis ; whence

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we are justified in saying, that vegetables are formed of these immediate materials.

VIII. Each of the materials above announced has peculiar distinguishing properties, among which those that can mark it's characters, and render it easily discernible from the rest, should be selected. It is by no means impossible, to treat this subject after the manner of botanists, and to have but one characteristic or specific phrase for each of these materials: and though this method has never yet been proposed or executed in chemistry, I shall endeavour to present a sketch of it in the succeeding sections, as I have already done with respect to acids and compound salts.

Characters of the immediate materials of vegetables.

IX. EXTRACTIVE MATTER, OR EXTRACT: dry; brown; a little deliquescent; soluble in water; obtained from the juices of
 vege-

vegetables by inspissation, or from decoctions or infusions of them by evaporation ; affording by distillation an acid, a little ammoniac, and some oil ; absorbing oxygen from the atmosphere, and by this absorption becoming gradually insoluble ; erroneously considered as a native soap ; composed of carbon, hydrogen, azot, and oxygen, and always tending to absorb more of the last than it contains in it's primitive state.

X. MUCUS, or MUCILAGE : an agglutinative, viscous, insipid substance ; affording much pyromucous acid on distillation ; soluble in both warm and cold water ; absorbing no oxygen from the atmosphere ; drying and becoming brittle in the form of gum ; existing in roots, young stalks, and leaves ; issuing from the bark of trees by expression ; gluing their fibres together.

XI. SUGAR : sapid and agreeable to the taste ; crystallizable, soluble, and fermentable ; in most circumstances resembling mucilage, but differing from it in the property

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of fermenting and forming alcohol. Both mucilage and sugar are compounds of carbon, hydrogen, and oxygen; differing from extract, 1st, by possessing a smaller proportion of hydrogen, on which account they do not absorb, like extract, the oxygen of the atmosphere; 2dly, by the absence of azot, whence they afford no ammoniac on distillation.

XII. ESSENTIAL SALT: comprehending the vegetable acids, formed in general of hydrogen and carbon more oxygenated than in the three preceding principles: accordingly these are convertible into acids by the addition of oxygen. Vegetable acids, however numerous they may be, appear to differ only in the proportion of their three principles: they are all decomposable by fire, capable of being converted into each other, and, on an ultimate analysis, are reducible to water and carbonic acid by the addition of oxygen. See Chap. VII.

XIII. FIXED

XIII. FIXED OIL : formerly called *gross* or *expressed oil* ; thick, sweet, inodorous ; burning when volatilized ; forming soap with caustic alkalies ; mixed with a mucilage named the sweet principle of oils by Scheele ; inspissating and becoming concrete by the contact of air and absorption of oxygen ; experiencing the same effects by the action of acids and metallic oxyds ; composed of carbon, hydrogen, and a little oxygen. It differs from the preceding compounds in containing a larger proportion of hydrogen : whence arise it's combustibility, and it's property of being converted into water and carbonic acid, when it burns with a sufficient quantity of air, as it does in the hollow wicks surrounded on all sides with air, which constitute Argand's lamp.

XIV. VOLATILE OIL : heretofore named *essential oil*, or *essence* : highly acrid, highly odoriferous ; entirely reducible to vapour at a heat of 184° ; combining difficultly with alkalies ; capable of being set on fire by acids ; inspissating to a resin by the action of

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oxygen ;

oxygen; burning more rapidly, and affording more water, than fixed oil, and admitting more speedily the precipitation of its charcoal, which forms lamp-black.

XV. AROMA: formerly called *spiritus rector*: a very volatile principle, reducible to vapour by the ordinary heat of the air, and forming an atmosphere round plants; passing over with water in distillation in *balneo Mariæ*; sometimes of an inflammable nature, at others displaying saline properties, uniting with alcohol, fixed oils, vinegar, &c.; forming by these combinations what are called in pharmacy distilled waters; contributing by its presence to the quantity of volatile oil distilled from plants, and bearing so great analogy to it, that they have been confounded together. The nature of aroma is not accurately known; some begin to suspect, that it is not a distinct body, a single principle disengaged from vegetable matters, but these matters themselves in substance reduced to a state of vapour.

XVI. CAMPHOR: a matter now recognized in a number of vegetables, and claiming to be reckoned among their immediate principles; of a concrete and crystalline form; very volatile; burning with the emission of smoke; soluble in a large quantity of water, in alcohol, and in ether; existing in several volatile oils; contained pure in the trunk and leaves of the species of laurel which furnishes it; too little known yet with regard to it's intimate nature; yielding a peculiar acid by means of the nitric.

XVII. RESIN: a soft or dry substance; little odorous; combustible; soluble in alcohol, but not in water; uniting difficultly with alkalies; little alterable by acids; originating from inspissated volatile oil, and appearing to differ from it only by a larger portion of oxygen.

XVIII. BALSAM: resin united with benzoic acid; more odoriferous than pure resin; affording it's acid in a concrete state by the agency of fire and water; yielding it to al-

kalies or earths; and approaching to resin after having lost it's acid.

XIX. GUM-RESIN: a concrete juice; partly soluble in water, and forming with it a kind of emulsion, as it does with vinegar, which has been supposed it's universal menstruum, but still more soluble in alcohol; not exuding naturally from vegetables like resin, but extracted from their ruptured vessels, in the form of a white or coloured juice, of a fetid smell more or less resembling garlic.

XX. FECULA: a pulverulent, dry, white, insipid, combustible matter; affording much pyromucous acid on distillation; soluble in boiling water, and forming a jelly with this liquid; convertible into the oxalic and malic acids by means of nitric acid; existing in all the white and brittle parts of vegetables, particularly in tuberosse roots and gramineous seeds; constituting the base of the nourishment of animals, and disposed to become readily a principle of their bodies.

XXI.

XXI. GLUTEN: an elastic, ductile body, as if fibrous or membranous; insoluble in water; slightly soluble in alcohol; affording a considerable quantity of ammoniac on distillation; putrescible like animal matter; turning yellow like it on the contact of nitric acid; convertible by this acid into oxalic acid; occasioning the difference between the farina of wheat and other farinaceous substances, and bestowing on it the capability of being made into a paste.

XXII. COLOURING MATTER: always attached to one or other of the preceding materials; appearing variable in it's nature; sometimes soluble in water, at others attackable only by alkalies, oils, or alcohol; indebted for the diversity of it's properties to the different quantities of oxygen fixed in it; possessing an affinity of attraction for alumen, oxyd of tin, &c.; and capable of combining more or less intimately with the textures of vegetables and animals.

XXIII. ELASTIC GUM: analogous to gum-resin; appearing to exist in several vegetables; remarkable for the extensibility and elasticity it retains after desiccation; affording ammoniac when distilled; diffusing a fetid smell when burned; having been at first in the form of a white milky fluid, and converted from that state to an elastic solid by the absorption of atmospheric oxygen.

XXIV. The LIGNEOUS PART, or WOOD: a matter too much neglected hitherto by chemists; constituting the solid basis of all vegetables, but far more abundant in those which are hard; erroneously considered as an earth; insoluble in water; affording on distillation the peculiar acid called pyroligneous; containing a large quantity of carbon; passing to the state of three or four acids by the action of the nitric; and appearing to be the last product of vegetation.

XXV. From what has been exhibited above respecting the immediate and known materials of vegetables, it follows, that they
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are all reducible, on an ultimate unalysis, to three or four principles, which are their primitive component parts ; namely hydrogen, carbon, oxygen, and, in many, azot ; and that they differ from each other only in the various proportions of the elements from which they are formed. Now if we investigate by simple calculation the number of different compounds, that may result from the union of three or four principles in every possible proportion, we shall find, that a much larger number might exist. But as each of the ternary or quaternary compositions which constitute the immediate materials of vegetables admits, as far as it appears, a certain latitude of proportions, while retaining it's general nature of extract, mucilage, oil, acid, resin, &c., it is easy to conceive, that the different proportions of the principles included within these several latitudes set bounds to the vast, immeasurable variety of colour, smell, taste, and consistency, which are observable in all the materials of vegetables, and which men discern in such
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of them as they employ in their food, garments, habitations, &c.

XXVI. On the same consideration it will not be more difficult to conceive, that vegetables must vary in the nature and specific properties of their materials, according to the several periods of their vegetation; that they can never remain in the same state; and that the different scenes exhibited in the periods of germination, leafing, blooming, fructification, and maturity, which constitute vegetable life, must be accompanied and marked by internal change, as they are by external appearance. Of this the variously modified taste, incessantly changing colour, smell not more stable, and difference of texture, which characterize the several epochs of vegetation, afford incontestible proofs.

XXVII. A new advantage arising from the present philosophy of chemistry is the having thus distinguished the nature of the materials of plants, far more complex than that of mineral substances. The acquisition

of this knowledge leads to an appreciation of the changes wrought in vegetable matters by different chemical agents. Thus we can no longer profess ourselves ignorant of the action of the destructive agent fire on vegetable substances. From the preceding considerations are understood how, when a complete vegetable, or any one of it's different products, is subjected to the action of fire, caloric tends to reduce these complicated compounds to more simple ones, by occasioning the union of their principles, two and two together, in proportions very different from those which before obtained. By gently heating them, the hydrogen is extricated, which burns alone, and much carbon remains : if they be strongly heated, the carbon is disengaged at the same time with the hydrogen, they both burn in the air, and the only residuum left consists of that small quantity of earth and salts, which constitutes vegetable ashes.

XXVIII. All the immediate materials of vegetables being reducible in their ultimate analysis

analysis to three or four original principles, namely, hydrogen, carbon, oxygen, and a little azot in some of them; this analysis moreover answering with the utmost precision to the manner in which vegetables are nourished, grow, spread, and perpetuate their species, since we know, that vegetation, to take place, requires only these simple principles; nothing more remains, but to find how plants appropriate these sorts of elements, and combine them in their organic strainers, to compose the different substances, the properties of which have been announced.

XXIX. It appears beyond all doubt, that water is the source whence vegetables derive their hydrogen; that they decompose this fluid in their leaves, by the help of the solar light, absorb it's hydrogen, which becomes fixed in them in the state of oil, or extract, or mucilage, &c., and separate it's oxygen, a great part of which, being dissolved in light and caloric, flies off in the state of vital air. But a portion of the oxygen of the water is fixed
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at the same time in the texture of the vegetable, in which it is retained chiefly by the carbon.

XXX. It is not so easy to account for the carbon that exists in vegetables. Some natural philosophers suppose, that vegetables decompose carbonic acid at the same time with water, and absorb it's carbon : but this supposition is not proved, though it has acquired strength, since the decomposition of carbonic acid combined with soda by means of phosphorus has been discovered. Other chemists are of opinion, that vegetable earths, mould, dung, and particularly the water of dunghills, furnish the carbon, attenuate, and even dissolved in water ; that plants absorb this principle by their roots ; and that they do not extract it from carbonic acid. According to this hypothesis, manure affords only carbon, and the water of it is nothing more than a saturated solution of this principle. To these data we must restrain at present the theory of vegetation.

Appli-

*Applications of the Results of the tenth
Chapter.*

The applications of the results delivered in this chapter are extremely multifarious ; they relate to agriculture, rural economy, pharmacy, materia medica, and all the arts in which vegetable substances are employed. The following is a slight sketch of the principal features of these important applications.

Germination.

The developement of leaves.

Blossoming.

Fructification.

The maturation of fruits and seeds.

The successive formation of gum, extract, oil, resin, salts, sugar, the colouring matter, and wood, in the different periods of vegetable life.

The growth of the woody substance, bark, &c.

The pharmaceutical preparations of juices, extracts, essential salts, mucilages, oils, refins,

refins, gum-refins, aromatic waters,
&c.

The arts of the sugar-maker, confec-
tioner, miller, baker, starch-maker,
vine-dresser, brewer, distiller, varnisher,
dyer, paper-maker, indigo-maker, co-
lour-man, flax-man, perfumer, oil-
man, soap-boiler, maker of charcoal,
&c.

C H A P. XI.

OF THE FORMATION AND NATURE OF
ANIMAL SUBSTANCES: THE THEORY
OF ANIMALIZATION.

I. IT is an established truth, that, without the aid of vegetables, animals cannot support their existence: accordingly it has long been said in natural history, that vegetables are formed from minerals, and animals from vegetables. But if this truth have been long known, the mode in which these bodies are changed, or reciprocally converted into each other, has never yet been ascertained. On this point, however, the labours of chemists should be principally exerted: for, were this problem once solved, it would lead us to a precise knowledge of all that concerns the animal economy: and some results conducive to this grand inquiry are

are already afforded us by modern discoveries.

II. The most certain means of solving this important problem are unquestionably first to acquire an accurate knowledge of animal substances, to compare them with those of the vegetable kingdom, and to investigate with care their difference or analogy. There is no doubt, were these differences once well known, they would enable us to understand the cause from which they arise.

III. If we compare the results of all the modern analyses made of the blood and humours, and of the solid parts which manifestly originate from the concretion of these, we shall find, that animal substances differ from vegetable substances in

A. The property of affording a considerable portion of ammoniac, and very fetid products, by the action of fire :

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B. In

B. In that of putrefying more easily, and more speedily, and giving out a far more noisome smell :

C. In yielding, when acted upon by nitric acid, much more azotic gas : and

D. In contributing singularly to the formation of nitric acid.

IV. All these differences seem to depend only on the presence of one principle in animals far more abundantly than in vegetables ; which is azot. It may be said, therefore, that the addition of azot to vegetable matters would suffice to convert them into animal substances.

V. Yet it is proper to observe, that to these primary differences, which may be termed *capital* ones, some other particular phenomena may be added, the influence of which, though undoubtedly inferior, on the animal composition, ought by no means to be neglected. Such, among others, is the presence
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of phosphoric acid, and the different phosphates, particularly those of soda, lime, and ammoniac, in the animal humours. To these salts are owing the peculiar quality of the coal of animal substances, especially it's being almost incombustible.

VI. The peculiar principle, which is so abundant in these substances, and more especially renders them different from vegetable matter, azot, appears, then, to be the efficient cause of the properties which distinguish them, and particularly of that sort of concrescibility, or plasticity, which will soon be considered more at large. It may be affirmed, therefore, that, if we were to deprive animal substances of azot, they would become again in some measure vegetables; as, to convert the latter into animal substances, it is sufficient to combine with them, or introduce into them, azot.

VII. Thus all the matters which form the bodies of animals may be considered as

so many immediate principles, as was done in the preceding chapter with regard to vegetables. In the same manner each of these principles ought to be characterized by the enumeration of it's most striking properties. If we so examine and describe the blood, milk, bile, fat, urine, &c., and the solids of animals, we shall obtain a comparative scale, which will exhibit the relations and differences that form the object of our search.

VIII. BLOOD : a red fluid ; warm at a temperature of 93° in man, quadrupeds, and birds ; at the temperature of the medium they inhabit in oviparous quadrupeds, serpents, and fishes ; sweetish ; coagulable by cold ; miscible with water ; separating almost spontaneously into three different substances, white serum, red serum or the colouring part, and fibrous matter ; exhibiting in each of these substances distinguishing characters, namely, in the serum, alkalinity, coagulability by fire, metallic oxyds, &c., coagulability owing to the more intimate combi-

combination of oxygen ; the same general nature in the red serum, which differs from the white only in the presence of oxyd of iron ; in the fibrous matter, or fibrin, spontaneous concrescibility, and solubility in alkalies. These principal characters ought to be considered in the whole of the blood, which appears to be the primary principle of all animal substances, the common origin of all the humours and of all the solids. It has been called fluid flesh, in consequence of the fibrin, which concretes in it on cooling. The cause of it's heat has been discovered in the alteration and absorption of vital air in respiration : and the renovation of the blood by the chyle, and the conversion of the chyle into animal matter, have in like manner been found to originate from the extrication of a considerable quantity of carbon and hydrogen, which appears to take place in the lungs.

IX. MILK : a white fluid, bland and saccharine, formed of serum, cheese, and butter, intimately mixed, and exhibiting a

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true

true animal emulsion. In the serum of milk we should particularly notice the substance called sugar of milk, which may be said to have the character only of an incipient sugar, and the quantity of phosphat of lime, more abundant than in the other humours, which seems to indicate, that nature thought fit to place in the first nourishment of animals a quantity of osseous base, with a view to the necessary celerity of the formation and growth of the bones in the earliest stage of their lives. The cheese is a true albuminous matter. The butter is a concrete oil, the solidity of which, and it's easy separation from the milk by simple agitation, appearing owing to the absorption of atmospheric oxygen during the formation of the cream.

X. BILE: an oily saponaceous fluid; composed of an oil approaching the state of spermaceti and soda, mingled with albuminous fluid; formed in the liver, a viscus which itself contains a large quantity of oil. In the system of the voluminous gland just mentioned, every thing indicates a disposition,

tion, an organization, designed to separate from the blood the large portion of fat, which arises from the retardation of this fluid in the venous system of the abdomen. This consideration, destined some day to become one of the principal bases of the physiology hinted at above, accounts for the bulk of the liver in the fœtus which has not breathed, as well as in animals which have no respiratory organ similar to those of man, birds, and quadrupeds. It also explains the origin of some diseases of the liver, particularly of it's concretions, or gallstones.

XI. FAT : a sort of oily matter ; formed at the extremities of the arteries, and as far as may be from the centre of motion and animal heat ; affording a kind of reservoir, in which that large quantity of hydrogen which could not be evacuated by the lungs becomes fixed ; an oil united to a considerable portion of oxygen, and containing besides sebatic acid. This manner of confi-

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dering

dering fat is one of the most striking points of modern physics as it regards animals.

XII. URINE : an excrementitious fluid ; more or less coloured, acrid, and saline ; remarkable for the large quantity of free phosphoric acid, and phosphat of soda, ammoniac, and lime, which it contains, and still more so for the presence of a peculiar acid, not yet found in any other animal humours, which is now called the lithic, because it forms the basis of the stones of the kidneys and bladder, which cause the disease known by the name of lithiasis.

Urine has been the source of discoveries highly valuable to the chemist, and must be of others still more valuable to the physician. Considering it first as a lixivium, designed to carry out of the body a large quantity of saline matters, which would injure the due exercise of it's functions, we must not forget that it is an evacuation, the proportion of the principles of which, varying according to the state of the body, becomes a kind of standard to show the

the modifications of the body, in health or sickness, by a series of observations, which physicians have already commenced under fortunate auspices. We should consider it, too, as always containing the matter of renal and vesical concretions, which seem to require for their formation only a little longer residence in the respective organs than nature intended, or the presence of a nucleus, which attracts, in some measure, the successive lithic strata. We must also observe the proportions of the different principles in the urine, particularly of the uncombined acids it contains, and the phosphat of lime which it carries along with it ; for these, differing remarkably in diseases of the joints, the aponeuroses, and the bones, will at some future period become, in the hands of skilful observers, new means of discovering the nature of these complaints, ascertaining their progress, and perhaps insuring their cure.

XIII. Little can be said here of the other animal fluids, such as the insensible perspiration, sweat, the gastric juice, saliva, tears, the
mucus

mucus of the nose, the cerumen, the feminal liquor, &c., because none of these fluids have yet been much examined. All have unquestionably their peculiar composition, and differ in some points, particularly in the proportion of their principles. Some of these humours, with which modern experiments have rendered us a little better acquainted, exhibit the union of a peculiar mucilage with water, pure soda, phosphat of lime, and phosphat of soda: such are the tears, the nasal mucus, and the spermatic fluid. Of these the first and second display likewise the property of inspissating by the contact of the air and the absorption of oxygen, which probably constitutes the maturity as it is called of the humours in catarrh, whether it be confined to the nose and fauces, or extend to the lungs. The feminal liquor has offered us the singular phenomenon of the crystallization of phosphat of lime, which was never before known.

XIV. On

XIV. On considering the whole of the solid matters which compose the various textures of the different organs of animals, the substances of which they are formed may be divided into three principal genera : the first comprehends the albumen ; the second, the gelatin, or gelatinous matter ; the third, the fibrin, or fibrous matter : two of these have already been distinguished under the article of blood, in the eighth section of this chapter. I shall do no more here than give a concise sketch of the constant phenomena, which may be considered as the characters of each of these genera.

G E N U S I.

ALBUMEN : coagulable by heat, acids, oxyds, and in general by oxygen in a concrete or nearly concrete state ; soluble by alkalies ; found more or less condensed or oxygenated, and interwoven in the membranes, tendons, cartilages, and, in general, all the white parts of animals.

G E N U S

G E N U S II.

GELATIN : participating the solidity of the first in most of the white organs, but capable of being separated from it, and easily dissolved by boiling water, to which it gives the form of a jelly on cooling. As it constitutes the base, or principal part, of all the white organs in general, these are more or less completely soluble in boiling water, and form transparent jellies by the refrigeration of these solutions.

G E N U S III.

FIBRIN : insoluble in water, at any temperature; soluble in acids; containing a large quantity of azot; condensed, concrete, and organised, in muscular flesh, which may be regarded as the proper receptacle of all the fibrin contained in the blood: accordingly, considering the muscles as the secretory organs of the fibrous matter of the blood, we ought to investigate all its modifications, with respect to the quantity or proportion
which

which fixes in these organs, and more particularly with regard to their apparent exclusion of it under various circumstances of disease, old age, &c.

XV. These three matters, albumen, gelatin, and fibrin, in a state of concretion, of combinations of two and two or all three together, and especially in different proportions, form all the solids of animals, and are separable from each other by a simple and easy analysis: they also, particularly the albumen, form many of the fluids of animals; only in these they contain less oxygen, more water, and are combined with acids, neutral salts, &c. It must be observed, that in the fluids the gelatin is as deficient as in the solids it is abundant, appearing to acquire it's nature of gelatin in passing from the fluids to the solids. Albumen dissolved in acids by art assumes properties analogous to those of gelatin.

XVI. The

XVI. The solid animal matter, or bony substance, is of another order of composition. A large quantity of an earthy salt, almost wholly insoluble, phosphat of lime, is amassed in the texture or primitive parenchyma of the bones. This is the whole mystery of the structure and composition of this part of the animal frame; and for this reason bones yield jelly on being boiled in water, and a considerable quantity of oil and ammoniac on distillation; and when thoroughly calcined, or burnt, they are nothing more than calcareous phosphat, mingled with some small portions of carbonat, muriat, and phosphat of soda.

XVII. When any one of the preceding animal matters, particularly of the condensed white fluids, or white organs, is treated with nitric acid, there will be extricated a more or less considerable quantity of azotic gas, and of prussic acid gas, which appears to be nothing but a combination of azot, hydrogen, and carbon, with a little oxygen. Gelatin yields the least, albumen
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somewhat more, and fibrin the most. In proportion as this change of combinations in the principles of animal matters is effected by means of the nitric acid, they seem to revert to their ancient state of vegetable matter, from which they do not essentially differ, as has already been said, but by the presence of azot, their proportion of carbon and hydrogen not being the same, and greater complication in the number of principles, from a combination of which they are formed. Thus instead of being ternary compounds, as vegetable substances are, animal matters are quaternary compounds, and even still more complicated. Azot is the fourth primitive principle, which is superadded to hydrogen, carbon, and oxygen.

XIII. Accordingly, the conversion of vegetable into animal matter, which consists only in the fixation or addition of azot, must be considered as the principal phenomenon of animalization : this alone explains it's chief mysteries ; and when once we are perfectly acquainted with the mechanism of
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this addition of azot, most of the functions of the animal economy, which effect it, or depend on it, will become equally known.

XIX. What we already know of the subject is confined to the following considerations. The phenomenon is not so much owing to the fixation of a new quantity of azot, as to the subtraction of other principles, which increase it's proportion. In respiration the blood exhales a large quantity of hydrogen, and of carbon, either simply dissolved in hydrogen gas, or converted into the state of carbonic acid by the very act of circulation, and in the vascular system, according to some modern philosophers. In the cavities of the bronchia, during the act of respiration, and by the instrumentality of this act, the hydrogen forms water, which exhales in expiration. A portion of oxygen appears at the same time to become fixed in the pulmonary blood, and, circulating with this fluid through the vessels, gradually combines with the carbon, so as to form that carbonic acid, which is extricated from the venous blood in
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the lungs. It is easy to conceive, that, by thus disengaging a large quantity of hydrogen and carbon, respiration must necessarily augment the proportion of azot. The study of the mechanism of the other functions, which remains to be pursued, will undoubtedly lead to new discoveries, still more important than the preceding : what has been performed within a few years naturally prompts us to imagine, that still more will be done. The analogy of action which has been discovered between digestion, respiration, circulation, and insensible perspiration, has begun to establish on new views, more solid than were heretofore possessed, a system of animal physics, which promises an abundant harvest of discoveries and improvements. Unquestionably it will be in pursuing the phenomena of digestion and growth in young animals, that an edifice equally novel and solid will be erected on these foundations. Every thing is ready for this grand work ; several philosophers pursue this unbeaten path of experience ; fresh ardour, springing from these new concep-

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tions,

tions, animates those who are engaged in this branch of physics ; and the track they have just begun to explore appears such as must lead them to more precise and accurate results, than any that have hitherto been advanced on the functions which constitute animal life.

Applications of the Articles in this Chapter.

The functions of the animal economy,
particularly

Respiration ;

Digestion ;

Hematosis, or sanguification ;

Insensible perspiration ;

The secretion of the bile :

Offification and osteogony ; and

Nutrition.

The diseases dependent on the degeneration of the humours, &c.

Animal concretions.

The action of various medicines on the humours, &c.

The arts employed in the manufacturing of animal matters, particularly those of the tanner, currier, preparers of different kinds of glue and size, makers of catgut, those who extract oils, and those who work on horn, bone, tortoiseshell, &c.

CHAP. XII.

OF THE SPONTANEOUS DESTRUCTION
OF VEGETABLE AND ANIMAL SUB-
STANCES.

I. WHEN vegetables and animals are deprived of life, or when their products are removed from the individuals of which they made a part, movements are excited in them, which destroy their texture, and alter their composition. These movements constitute the different kinds of fermentation. The intention of nature in exciting them is evidently, to render more simple the compounds formed by vegetation and animalization, and to cause them to enter into new combinations of different kinds. When a portion of matter has been employed for some time in the fabrication of an animal or vegetable body, it must be rendered up by it to form new compositions, as soon as the functions of the body are at an end.

II. From

II. From the general definition of fermentation it would seem, that there ought to be as many peculiar and different fermentations, as there are vegetable and animal matters to be changed and decomposed : but several of them pursuing a similar path to arrive at a more simple state of composition, the number of fermentations has been reduced to three, the vinous, acetous, and putrid.

III. Vinous fermentation, as it's name imports, is that which produces wine or alcohol. The saccharine matter is the only one which undergoes this fermentation, when diluted with a certain quantity of water, and mingled with a third substance of some kind, vegetable or animal, as extract, salt, fecula, or the like; for it is now fully proved, that sugar and water alone never enter into vinous fermentation. The saccharine matter is so abundant and generally diffused through vegetable and even animal substances, that there are a great number of bodies capable of affording wine, or yielding alcohol. All sweet and saccharine fruits reduced to a pulp, and

more especially their expressed juices, undergo a movement, when they are at a temperature of 62° or upwards, if they be in a large body, and particularly when neither too thick nor too thin. Hence the great number of different wines, comprehending the decoctions of grain malted, and by this process converted in part into saccharine matter, and even the vinous liquors made with milk, honey, blood, &c.

IV. Vinous fermentation announces itself in saccharine liquors by an increase of volume, the formation of a copious scum which covers their surface, rise of temperature, the disengagement of a considerable quantity of carbonic acid gas, and the conversion of a sweet fluid into a sharp, warm, and pungent liquor.

V. The cause of this fermentation appears to be owing to a decomposition of water, a great part of the oxygen of which, attacking the carbon of the sugar, burns it, and converts it into carbonic acid. At the same time the hydrogen of the water attacks the
sugar

sugar divested of it's carbon, and, combining with it, gives birth to alcohol. Thus alcohol may be defined to be sugar minus a certain quantity of carbon, and plus a certain portion of hydrogen. This theory explains both the formation of the carbonic acid evolved during the progress of vinous fermentation, and that of the alcohol, as well as all the properties of this new production.

VI. Pure alcohol is a white liquid, of a strong smell, of a hot and acrid taste; rising in vapour at a temperature of 150° ; inflammable at any temperature; affording much water and carbonic acid in burning; yielding no smoke in combustion; miscible with water in any proportion, and expelling it's air and a part of it's caloric while combining with it; dissolving pure or caustic alkalies; decomposing acids, and convertible into ether by this decomposition; dissolving deliquescent neutral salts, and several metallic ones; taking from vegetables their volatile oil, aroma, resin, balsam, part of their gum-resin and many colouring matters: finally, of use in various processes of the arts in consequence of these several properties.

VII. The reader may have already remarked, that the formation of alcohol takes place at the expence of the destruction of a vegetable principle, and that the saccharine matter undergoes a decomposition, which reduces it to a more simple term; thus vinous or spirituous fermentation is a commencement of the destruction of principles formed by vegetation: and thus it may be regarded as one of the movements established by nature, to simplify the order of composition, which vegetable substances exhibit.

VIII. The acid or acetous fermentation is the second natural movement, which contributes to reduce vegetable compounds to more simple states of composition. This fermentation, which produces vinegar, takes place only in liquors that have previously undergone the vinous fermentation. It has been observed, that the contact of air is necessary to the production of vinegar: it has even been perceived, that wine in turning sour absorbs air; so that a certain portion of the oxygen of the atmosphere appears to be necessary to the formation of the acetous acid.

IX. Un-

IX. Unquestionably there are several other fermentations analogous to that which forms vinegar, though their products are not yet well known, such for instance are that of water mixed with starch, called starch-makers four water, and those which form four bread, four kraut, and four liquors. All these changes are to be considered as means of decomposition for simplifying the complex combinations of vegetables.

X. Finally, after vegetable liquors, or their solid parts moistened, have passed to the acid state, their decomposition, continuing under favourable circumstances, namely a gentle or warm temperature, exposure to air, and the contact of water, leads them into putrefaction, which terminates in volatilizing most of their principles under the form of gas. Water, carbonic acid, carbonated and even sulphurated hydrogen gas, volatile oil in vapour, and sometimes even azotic gas and ammoniac, are evolved; and after this there remains nothing but a brown or black residuum, known by the name of mould, formed of carbon somewhat fat and oily,

from which water still extracts some saline substances and a little extractive matter.

XI. Nature, in organizing animals, and forming their fluids and solids by complex compositions, has placed in them a germ of destruction, which develops itself after the death of the individual.

This destruction is effected by the movement termed putrefaction, which consists in a kind of fermentation, a slow decomposition of the solid or fluid substances. Their order of composition, being more complex than that of vegetable matters, renders them still more susceptible of the putrid decomposition.

XII. Animal substances composed of hydrogen, carbon, oxygen, and azot, and frequently still more complicated by the union of sulphur, phosphorus, &c., when deprived of that movement, and more particularly of that renovation, which constitute animal life, are soon altered by more simple attractions between their principles, which have a tendency to unite two and two together.

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This reaction gives birth to binary compounds, such as the carbonic acid, nitric acid, ammoniac, and carbonated hydrogen gas, which gradually escape into the atmosphere, proportionally diminishing the quantity of animal matter. It is thus, in consequence of a natural decomposition, that we perceive this animal matter soften, change colour and smell, lose its texture and form, and diffuse through the atmosphere vapours and gases, which dissolve in the air and transfer to other bodies, particularly those of vegetables, the materials necessary for their formation.

XIII. All the phenomena of the putrefaction of animal substances depend on the mechanism here explained. In the union of hydrogen and azot we perceive the formation of ammoniac, which has been deemed the principal offspring of putrefaction. The combination of carbon with oxygen explains the generation and evolution of carbonic acid, in which all the mystery of putrefaction was made to consist, about the time when gases were first discovered. Nitric acid, to the production of which it is well known

known how much animal substances contribute in artificial nitre-pits, arises from the union of oxygen with azot. A certain quantity of hydrogen gas is extricated, and carries off with it carbon, sulphur, and even phosphorus: hence the various noisome smells, and perhaps the phosphorescence, of all putrefying animal matter.

XIV. When all these volatile principles have united two and two together, and diffused themselves in the atmosphere, nothing remains but a portion of carbon, combined or mingled with fixed saline substances, such as the phosphats of soda and of lime. These residua form a sort of mould termed *animal earth*, which frequently retains a little sulphurated and carbonated hydrogen gas, fat, and extract, and in this vegetables find in abundance the principles requisite for the formation of their materials. It is on this account, that the residuum of animal matter is so proper for manure, when sufficiently concocted.

XV. A certain portion of water is necessary for this putrid decomposition of animal
sub-

substances : it furnishes them with the quantity of oxygen necessary to the composition of carbonic and nitric acids ; and it contributes highly to the production of the putrefactive movement, by the attractions of the oxygen it introduces to them. It is equally indubitable, that the hydrogen arising from the decomposition of this water contributes greatly to the formation of ammoniac : for it is a well known fact, that, when animal matters are diluted with a large quantity of water, they furnish abundance of ammoniac in their decomposition.

XVI. Putrefaction, consisting in a series of particular attractions, is modified in many different ways by external circumstances, such as temperature, the medium the animal substance occupies, the state of the atmosphere, whether more or less light or heavy, moist or dry, &c. Thus dead bodies buried in the earth, immersed in water, or suspended in the air, are differently affected ; and moreover their bulk, their quantity, their propinquity to other bodies, and all the varying properties of the three mediums
above

above enumerated, diversify the effects produced.

XVII. We have proofs of this assertion, in what happens to bodies interred singly, and those which are buried in numbers heaped on one another. The former, surrounded with a large quantity of earth, are soon destroyed by putrefaction ; the aeriform or liquid products of which are absorbed by this earthy mass, or by the atmosphere. The latter, not having around them this kind of earthy or atmospheric recipient, remain a long time without being destroyed ; and the animal matter is wholly converted into ammoniac and concrete oil, which are known to form a soap similar to that which is found in the soil of burying-places surcharged with dead.

XVIII. The phenomena attending the destruction of animal substances immersed in water are likewise different. As new products are formed, the water dissolves them, and transmits them to the air. Continual moisture, with a constant temperature some degrees

degrees above 32° , favours the putrefaction of these substances, and their dissolution into a state of gas. On the contrary, a hot and dry air, volatilizing the water, desiccates and hardens the bodies of animals, and preserves them almost as well as the dry and burning sand of Egypt, so abounding in natural mummies.

XIX. Though all the circumstances of putrefaction; and the almost innumerable varieties of the phenomena they exhibit, are not yet described, or even known, we have discovered, that they are confined to the conversion of complex substances into substances less compound; that nature restores to new combinations the materials, which she had but lent as it were to vegetables and animals; and that she thus accomplishes the perpetual circle of compositions and decompositions, which attests her power, and demonstrates her fecundity, while it announces equal grandeur and simplicity in the course of her operations.

Appli-

Applications of the Propositions of the last Chapter.

Beside the subjects mentioned at the end of the two preceding chapters, to which the articles of this almost directly apply, we find, in the several facts here enumerated, the following applications.

The preservation of all substances extracted from vegetables.

The several spontaneous alterations they undergo, the acetous fermentation, the vinous, &c.

The products of these alterations, frequently employed for the purposes of the arts.

The production of ammoniac and nitric acid.

The influence of putrefaction in the different regions of living bodies.

The contagion and maladies produced by the effluvia of putrefied substances.

The theory of the situation and management of hospitals, drains, sinks, lay-stalls, cemeteries, &c.

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